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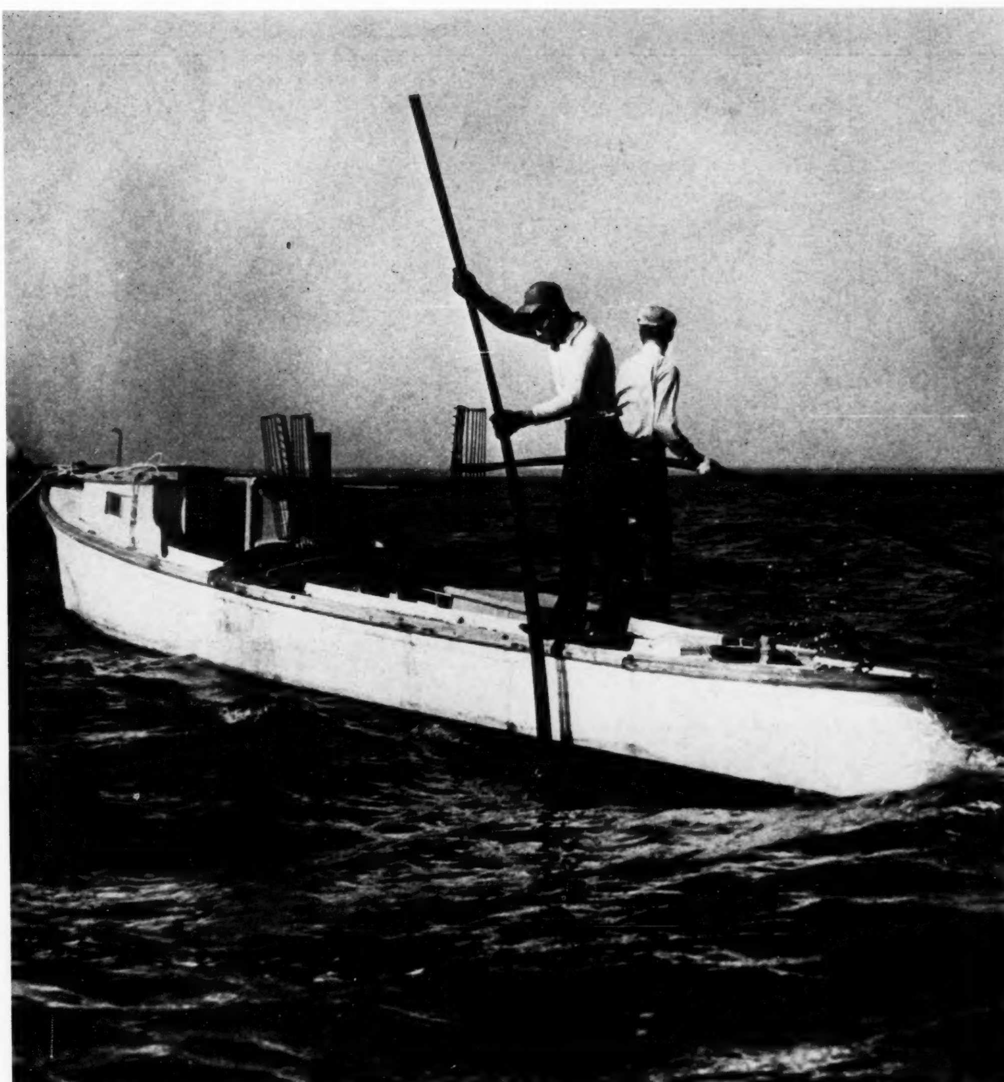
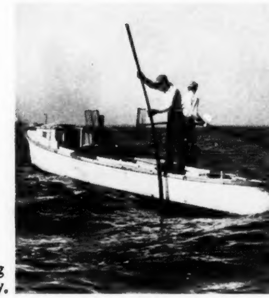


Enhancing Molluscan Shellfisheries

Marine Fisheries REVIEW



On the cover: Tonging oysters in Chesapeake Bay.

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A Guide for Enhancing Estuarine Molluscan Shellfisheries

CLYDE L. MacKENZIE, Jr.

Part I: Enhancing Estuarine Molluscan Shellfisheries

Introduction

In the eastern United States as well as in many countries where most shellfish originate in public beds, shellfishermen, local communities, distributors, and consumers have been dependent on wild stocks for shellfish supplies. Abundance of shellfish is usually much lower than the carrying capacity of the beds and can fluctuate widely among seasons. Thus shellfisheries are built upon a relatively weak foundation: Uncertin supplies, abundance of which is governed by several natural factors.

In the eastern United States, the most important estuarine shellfishes are the American oyster, *Crassostrea virginica*; hard clam, *Mercenaria mercenaria*; soft clam, *Mya arenaria*; and bay scallop, *Argopecten irradians*. Beds of the hard clam, soft clam, and bay scallop remain uncultivated.

Consequently, production has usually not been high enough to make shellfisheries very prosperous, and the market demand for shellfish cannot be met when supplies are scarce. Whenever supplies are limited, employment for fishermen and packing plant workers is low, supplies are small and prices are high in the marketplace. Somewhat of an exception is the oyster fishery, where oyster abundance has been increased and partially stabilized through shell plantings in several states, such as Maryland, and through predator control in Long Island Sound.

Many acres of productive shellfish beds along the eastern United States have been closed because they have become polluted or degraded by filling or dredging of navigation channels. As a result, fishermen have often lost considerable fishing areas, which in turn has led to a considerable loss of employment and wealth. In the future, communities or states should be able to compensate their shellfisheries for these losses by supporting programs to increase shellfish abundance on the remaining beds by improving habitat quality. This would ensure that the shellfisheries would remain intact, stable, and without substantial losses.

The need to increase yields from shellfish beds has often been recognized (Belding, 1912; Walford, 1945; Galtsoff, 1964). Some development has occurred in oyster beds and many hatcheries for rearing oyster and hard clam spat now exist in eastern United States. Recently, manuals have been published for producing seed in hatcheries (Breese and Malouf, 1975; Dupuy et al., 1977; Castagna and Kraeuter, 1981; Jones and Jones, 1983) that demonstrate it is a viable technology.

Can the abundances of hard clams, soft clams, and bay scallops be increased by culturing beds? Possible methods include improving the bottom for settling larvae and controlling predators of juveniles. Can oyster beds be improved further? Any person who attempts such shellfish husbandry will find little literature available for guidance. Published shellfish papers list only some of the predators and other factors which limit the abundance of various shellfish species. Little detail about these factors in specific beds is provided; even less exists about efforts to control them or about the other steps which could be taken to increase shellfish abundance.

Enhancing shellfish beds also involves interacting with fishermen, local citizens, politicians, fishery administrators, and managers of private beds. Such interactions are more comprehensive and require far more guidance and understanding than the management and control of limiting factors in shellfish beds. The person who tackles a job of shellfishery enhancement faces a myriad of problems in shellfish ecology, technology, and social phenomena for which little training or guidance exists.

This guide was prepared as a manual for management biologists (hereafter denoted as shellfish production specialists), marine extension agents, and administrators to use for increasing the abundance and production of most shellfish in public and private beds in estuaries and bays of the eastern United States. The emphasis is on increasing abundance by improving shellfish bed environments and developing communication between participants in the shellfishery. The intent is to be supportive of fishermen, rather than confrontational.

This guide describes what aspects to study in shellfish beds and what steps to take to determine and then control the limiting factors of shellfish abundance and production. In addition, it discusses how a specialist should interact with fishermen, lay people, fishery administrators, and politicians in a shellfishing community. This guide does not contain

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all the answers, since nearly every situation demands a uniquely tailored approach and solution. Nevertheless, the ideas presented should help to enhance shellfisheries.

Part II of this guide provides reference material including: 1) A discussion of shellfish distributions and yields, 2) a statistical summary of the shellfishing industry, 3) a discussion of the life cycle and ecology of shellfish, and 4) a description of the characteristics of shellfisheries and shellfishermen of the eastern United States.

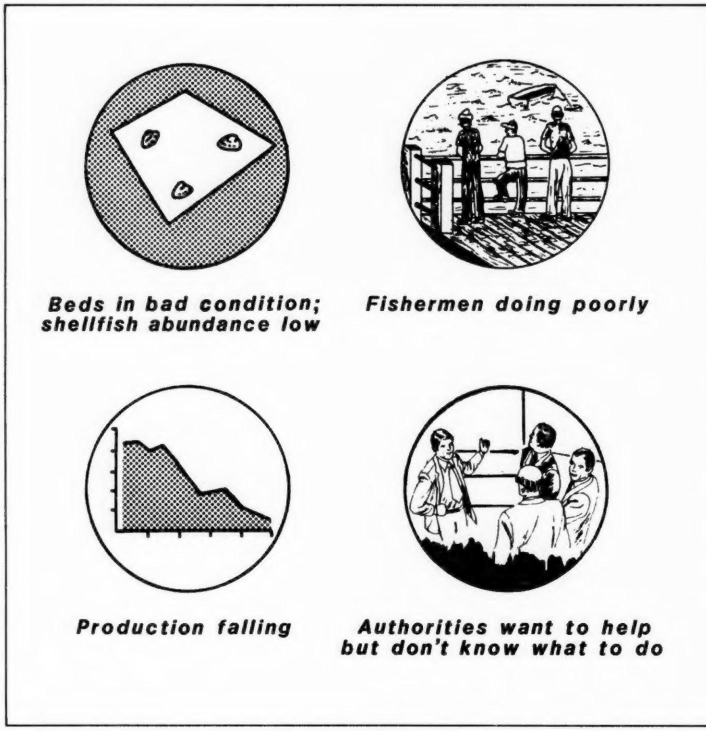

Figure 1.—An illustration of the depressed situation in a number of shellfisheries.

Developing Enhancement Programs: The Agricultural Experience

An enhancement program for shellfisheries would be closely related in concept to agricultural development programs. Thus many of the same difficulties that existed in developing such programs are relevant to the development of shellfishery enhancement programs.

New agricultural programs are always beset by a wide range of problems as the following quote demonstrates: "My mission was not much of a success. This was not because the government was not anxious to go ahead with the program, but helping really poor people is never easy and the difficulties of a new program often turn enthusiasm into procrastination" (Garst, 1963).

Likewise, there are often statements about development of the wrong things or products: "Despite a great amount of hard work and money spent, development fails to happen. The fault lies not with the humans nor with lack of money. The fault lies deep within the development projects themselves. Even before the first shovel is turned, even before the appropriated money reaches the palm trees or the arid lands, the wrong decisions have been made, the decisions to develop the wrong things" (Paddock and Paddock, 1964).

Often programs are poorly implemented: "Too many poorly thought through government policies and programs or ineffectively implemented programs can be in some cases even more stifling to agricultural growth than a lack of needed programs" (Stevens, 1977).

Concerns about the origin of programs are often included: "The key to agricultural development efforts is that they start where the people are. They are not schemes worked out in a government office where physical targets are the main objectives and the people must fit in." (Stamp, 1977).

In recent years, substantial advances have been made in developing the capacity of agricultural research systems to deliver technologies, programs, and products that meet the needs of farmers. For several early decades, most agricultural research was conducted at research stations under conditions not representative of farmers' fields, and it had little or no farmer involvement. Recently, however, new, on-farm research is conducted in farmers' fields with farmer participation. On-site experimentation ensures that technologies are formulated under "field" conditions and leads to estimates of yield and cost changes that better reflect what farmers can expect from using a variety of alternatives. The final phases of the on-farm research have assessed farmers' experiences with the recommendations as well as promoting recommendations to other farmers. When farmers rejected or substantially modified recommendations, learning why has led to appropriate changes in the recommendations.

Increasing Shellfish Abundance

Low and variable shellfish abundance in public and private beds causes severe

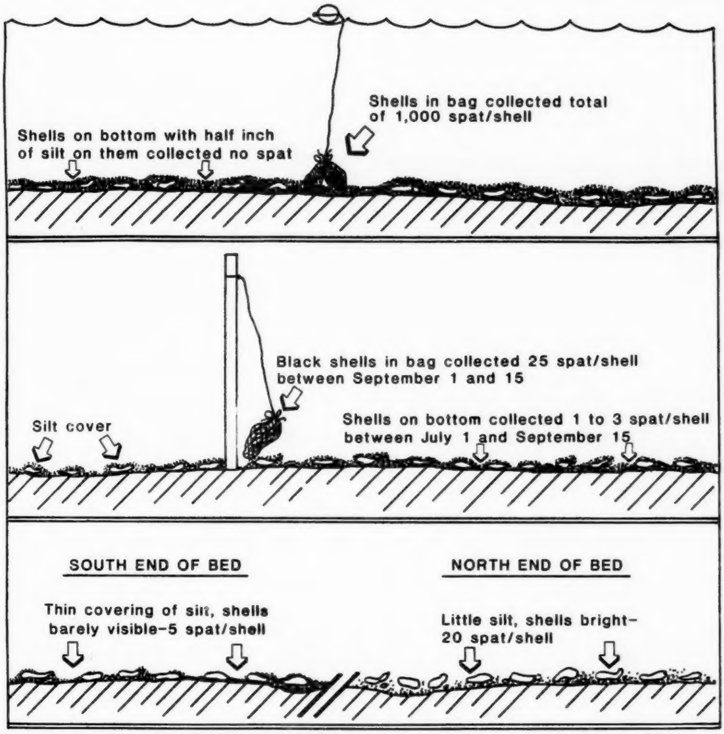

Figure 2.—Some observed effects of silt on setting densities of oyster spat in Connecticut in 1968.

negative economic and supply repercussions (Fig. 1). We must acknowledge that the problem exists, and we should not believe that permanent increases in shellfish abundance will be achieved accidentally. Only changes made by humans can increase shellfish abundance permanently.

My colleagues and I have examined many shellfish beds with scuba gear in a number of states. We have observed that most beds contained or lacked various biological and physical factors which substantially limited shellfish abundance. The productivity of oyster beds was commonly limited by silt deposits (Fig. 2), fouling organisms on shells, and a scarcity of shells as cultch for larvae. Predators were abundant on high salinity beds and often destroyed most seed oysters. While clam and bay scallop beds have not been viewed as frequently, some hard clam beds had many predators (crustacean and gastropod) present, and bay scallop beds often had eelgrass concentrations which were too dense for the scallops.

The Basis for Increasing Shellfish Abundance

The approach to increasing shellfish abundance by removing limiting factors (or adding supporting factors) is analogous to increasing agricultural crops and wildlife on land. Techniques would be applied to foster the production of target crops or species. The principal supporting features for shellfish, i.e., the bottom, the water, and the food, are already provided; humans would intervene to modify or husband the wild environment slightly "to help mother nature along." As mentioned, oyster abundance has been increased in most coastal states by spreading shells on the bottom to increase the area of suitable setting surfaces for ready-to-set larvae. Controlling predators and reducing suffocation in silt-laden habitats have also been found effective in increasing survival of seed oysters in Long Island Sound.

Spreading shells on clam beds may provide cover from crustaceans. Cutting paths through eelgrass stands, if they are too dense, or planting eelgrass where it is absent, and perhaps removing fish from bay scallop beds may help. Transplanting dense populations of seed shellfish to beds having good environments but relatively sparse populations or modifying the sizes of openings and channels in bays and estuaries will also provide for increased recruitment and growth.

Other limiting factors may be reduced as they are identified. Technologies exist or could be designed or modified from existing ones, for washing silt off shells with a board, spreading shells and transplanting seed, removing crabs from the bottom with a predator board-net (MacKenzie, 1979), adding cover to clam beds (Castagna, 1970; Castagna and Kraeuter, 1977), controlling predators with quicklime (MacKenzie, 1970), and cutting or planting eelgrass.

Environmental Side Effects of Improving Beds for Shellfish

Economic enhancement of a shellfishery and the modifications of shellfish beds must not be permitted to flourish at the expense of the total habitat. It is assumed that the beds would return to their earlier condition if culture were to cease. This section discusses the side effects of some of the major actions which might be taken to improve shellfish habitats.

Silt removal from seed beds can result in some additional silt deposition on nearby bottoms. The quantity of silt would be no larger, however, than that ordinarily raised from the bottom and redeposited as a consequence of high winds or washed into the water by rain from land; thus, effects on water turbidity or benthic organisms would be no larger than from natural events.

Any mechanical methods for removing predators would be used mostly during

summer and fall and then only for brief periods. The new ratio of predator to prey would be similar to one that occasionally occurs in beds when predators become scarce from natural causes and shellfish populations respond by becoming unusually abundant. Predator reduction in beds may be followed by increase in numbers of associated invertebrates.

The use of quicklime as a control method would be at most only temporarily harmful to marine life. Scuba observations of several oyster seed beds immediately before, during, and after quicklime treatments to control starfish (MacKenzie, 1977a) have shown that quicklime, by contact, kills algae, such as diatoms, and animals, including starfish, bryozoa, and sponges. It does not harm tissues that it does not contact or cover, such as bryozoa or sponges on the underside of oysters, or oysters, clams, crabs, and finfish.

Table 1.—Summary of some characteristics of four major shellfish predators in Long Island Sound.

Item	Starfish	Oyster drill	Xanthid crab	Rock crab
Population density[1] (no./m^2)	1-6	15-20	56	3-4
Pelagic larvae	Yes	No	Yes	Yes
Juvenile consumption of juvenile shellfish	Yes	Yes	Yes	Yes
Maximum size of oyster which adult can consume[2]	7.5 cm (3")	?	1.0 cm (0.4")	2.5 cm (1")
Specific density	Low	High	Low	Low
Attachment to objects	Strong	Medium	None	None
Can burrow	No	Near surface in winter	Sometimes	Sometimes
Mobility	High	Low	Low	High
Migrations	Extensive	Slight	Slight	Extensive
Period of dormancy	None	Five winter mo.	None	None
Minimum salinity tolerated	18 ppt[4]	15 ppt[5]	Extremely low	15 ppt[6]

[1]Adults only.
[2]The values are generally accurate, but exceptions are common.
[3]Carriker, M. R. 1955. Seasonal movements of oyster drills (*Urosalpinx cinerea*). Proc. Natl. Shellfish. Assoc. 45:190-198.
[4]Galtsoff, P. S., and V. L. Loosanoff. 1939. Natural history and method of controlling the starfish (*Asterias forbesi*, Desor). U.S. Bur. Fish., Fish. Bull. 31:75-132.
[5]Carriker, M. R. 1955. Critical review of biology and control of oyster drills *Urosalpinx* and *Eupleura*. U.S. Fish. Wildl. Serv., Spec. Sci. Rep. Fish. 148, 150 p.
[6]Estimated.

Table 2.—Positive and limiting features and recommended remedies to rehabilitate oyster beds in Connecticut.

Positive features
1. Moderate oyster productivity: Adequate setting potential on some beds between Bridgeport and New Haven about once every 2 years; growth from spat to market size in 4-5 years; and good oyster survival when predators and silt are insubstantial.
2. Adequate salinity over 30,000 or more hectares (75,000 acres).
3. Excellent hard bottom.
4. Ample areas offering good protection from storms.

Beds in:	Limiting features	Recommended remedies
Norwalk Harbor	1. Significant oyster drill predation.	1. Polystream application.[1]
	2. Suffocation in silt.	2. Earlier transplanting.[1]
Bridgeport		
Natural seed bed	1. Sand bottom with no surface shells.	1. Spread shells over bottom.
Private beds	1. Fouling on shells.	
Housatonic River	1. Suffocation in silt.	1. Allow fishermen to use hand dredges.[1]
Milford beds	1. Fouling on shells.	
New Haven Harbor	1. Insufficient shells.	1. Concentrate available shells on best bed.[1]
	2. Starfish predation.	2. Quicklime application.[1]
	3. Suffocation in silt.	3. Earlier transplanting.[1]
	4. Fouling on shells.	4. Heavy quicklime application.

[1]Method was implemented.

Previous Human-induced Shellfish Increases

Oyster

The principal oyster producing states (see Part II) sponsor programs to maintain oyster beds as public grounds. Collectively, the programs first involve the mining and spreading of several million bushels of shells and later the transplantation of seed oysters.

The programs have resulted in large cost-benefit ratios. For example, Whitfield (1973) stated that human-established oyster beds in Florida which produce for 20 years, as some already have, result in a cost-benefit ratio at the fisherman's level of at least 1:100. He stated further that oyster bed rehabilitation in Louisiana had resulted in cost-benefit ratios as high as 1:20.

I have been involved in three oyster rehabilitation programs. The first was in Long Island Sound during 1966-72 and involved mostly a private oyster fishery. When the work was begun, the industry was depressed; only two oyster companies of substantial size remained in Connecticut. Only small quantities of oysters remained on the beds, and production was extremely small. In the 1930's, at least 30 companies, including relatively small ones, were operating, but nearly all had since gone out of business. The basic need of the remaining companies was to increase oyster abundance.

I conducted a 5-year study of the industry with an emphasis on determining the factors which limited production. Much of the work involved scuba observations of setting beds and beds of growing seed, using company boats with the manager of the company nearly always present. I found that less than 1 percent of the bottom area off the Connecticut coast was suitable for receiving oyster sets; thus, nearly all oyster larvae had no place to set and died. On many beds I made counts to determine the relative quantities of oysters killed

Table 3.—Positive and limiting features and recommended remedies for oyster beds in Prince Edward Island.

Positive features
1. Above average oyster productivity in Bedeque Bay and East River: Adequate setting virtually every year; growth from spat to market size in 4-6 years; and good oyster survival.
2. Adequate salinity over large areas, but in lower East River it was sufficiently high to allow habitation by starfish.
3. At least 400 hectares (1,000 acres) of hard ground.
4. Ample areas offering good protection from storms.
5. The above areas also had ideal water depths, 1-11 m, for easy harvesting
6. These areas also had tube worms in numbers.
7. There were several million bushels of shells available in buried deposits.
8. Unharvestable oyster stocks were available in Bedeque Bay (150,000 bushels) and East River (150,000 bushels).

Beds in:	Limiting features	Recommended remedies
Bedeque Bay	1. Beds in most favorable areas were barren.	1. Transplant nearby oyster stocks to barren beds.[1]
East River	1. Beds in most favorable areas were barren.	1. Transplant nearby oyster stocks to barren beds.[2]
	2. Some starfish predation would occur on deep beds.	2. Quicklime application.[2]

[1]Since 1974 oyster abundance in Bedeque Bay has been increased by spreading shells obtained in Malpeque Bay over barren beds.
[2]Method was implemented.

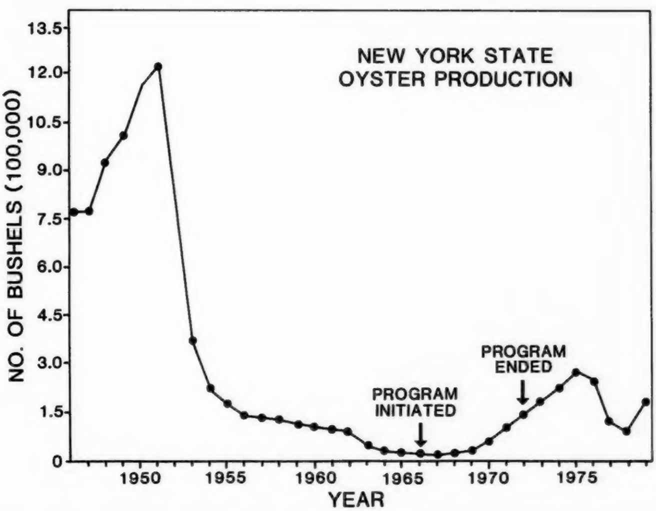

Figure 3.—Oyster landings in New York in a 34-year period, 1946-79. The oyster enhancement program began in 1966 and ended in 1972. (Sources: Lyles, 1969; Anonymous, 1946-79.)

by each predator species and other factors and the months during which mortalities occurred. I found that predation by starfish, *Asterias forbesi*, and oyster drills, *Urosalpinx cinerea* and *Eupleura caudata*, during the warmer months and smothering by silt in early April caused most mortality. In addition, mortalities were highest during the first and second years of the oyster's life. Table 1 lists some characteristics of predators learned through scuba observations during that study.

I worked with company managers to develop the means to improve the condition of setting beds and control mortalities (Table 2). We discussed possible improvements during many one-on-one meetings on their boats and during telephone conversations.

I informed the companies that only a small number of their setting beds were in condition to receive sets of oysters. During 1966-72 they improved their setting beds somewhat by spreading more clean shells on them.

One of the companies had been controlling starfish by spreading quicklime over its beds, while the other was using only ineffective mops for this purpose. After the latter was informed about the effectiveness of quicklime and its efficiency was demonstrated on its beds, it began to use quicklime on a substantial scale.

Another method to control oyster drills was developed by the Milford Laboratory of the NMFS Northeast Fisheries Center. This was the spreading of Polystream[1] (a mixture of chlorinated benzenes) over oyster beds. I demonstrated its effectiveness to companies on their beds and they used it thereafter. After a few years, Polystream was banned, but while using it, the fishermen had recognized the enormous mortalities that oyster drills had inflicted on oysters. Therefore, after it was banned, suction dredges were used to control oyster drills.

I also showed these companies that silt smothering mortalities could be reduced by rescheduling the transplanting of their oysters from late April-May to late March-early April. The total result of all these improvements in oyster culture was that oyster abundance increased several times over and oyster production increased enough to be considered as a "yield take-off" (Fig. 3).

The second oyster rehabilitation program I worked with was in Prince Edward Island, Canada, during 1972-73 (Table 3). It involved a public fishery, and when the work was begun, the industry was depressed. Oyster production had been declining for about 25 years and many fishermen had left the fishery; those remaining had critically low incomes. The fishermen had always gathered oysters from natural beds which had never been enhanced. The Provincial Department of Fisheries provided a full-time associate, a native of the

[1]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

area, to work with me. Using scuba and other means, we found by extensive surveying of the oyster estuaries that: 1) Oysters were scarce or absent on several former oyster beds, 2) little predation of oysters occurred on the beds, 3) relatively large stocks of unfished oysters occurred on an extensive flat in one bay and in a 10-12 m (36-foot) channel in a river, and 4) huge quantities of fossil oyster shells were present in several estuaries. Fishermen and other local residents were interviewed extensively, one-to-one, in their homes, on their boats, and by telephone. We also issued newsletters and held a few public meetings. The fishermen's basic need was for a larger oyster supply.

We recommended that the Province construct an oyster boat to transplant oysters and shells to the barren beds (Table 4). An efficient catamaran using two lobster boats as hulls was built. A captain and two deckhands were the only crew; they could load it to a capacity of 250 bushels of oysters in about 2.5 hours. Leading fishermen were asked to point out beds on which to spread the oysters and shells. From 1972 through 1986, oysters were transplanted to good quality barren grounds in some years, and fossil shells were transplanted to those grounds in most years. As a result of the program, oyster production more than tripled (Fig. 4).

A third oyster rehabilitation program was initiated in Mississippi and involved the recovery of three types of reefs (Tables 4, 5). The program lasted only a few weeks and was too short to yield substantial results.

Table 4.—Technologies and methods adopted by oyster fisheries and approximate extent of use in Long Island Sound, 1966-72; Prince Edward Island, 1972-89; and Mississippi Sound, 1975.

Area and methods	Extent used
Long Island Sound	
1. Use of quicklime to control starfish.[1]	3,000 tons/year.
2. Use of Polystream to control oyster drills.	80 hectares (200 acres) total.
3. Rescheduling of transplanting oysters.	100,000 bushels in 1967.[2]
4. Modified oyster dredge.	10 vessels.
Prince Edward Island[3]	
1. Transplanting seed oysters and spreading shells with vessels, including a catamaran.	Used on public beds for several years.
2. Hand dredge to replace hand and tonging.	One or two leaseholders for several years.
3. Use of quicklime to control starfish.	About 8 tons/year in some years.
Mississippi Sound	
1. Boom dredging system on transplanting vessel.	8,000 bushels transplanted in 1976.
2. Pressure board for mud removal.	Tested in 1975 on 18 hectares (45 acres); results limited.

[1]Use of quicklime was already used in the fishery, but its use and value were unknown to most companies.
[2]Quantities after that year are unknown.
[3]Besides the three technologies and methods used, the Federal government supported a program in which fishermen transplanted overcrowded oysters to good bottoms. The program continued through 1985, and has been responsible for about 10 percent of the increase in production from 1972 to 1984 (Fig. 4).

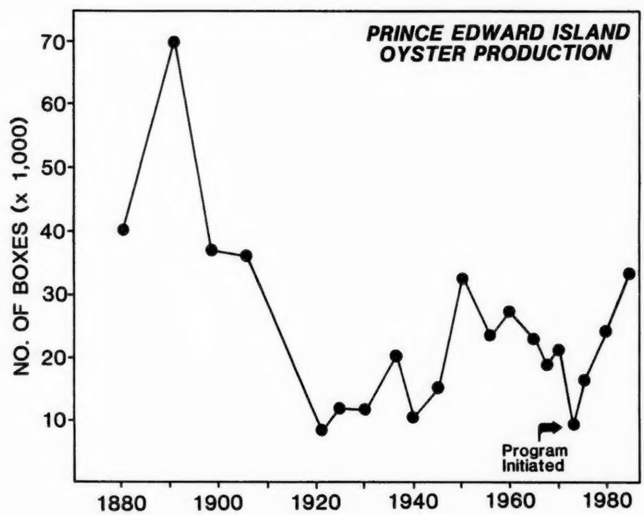

Figure 4.—Oyster landings in Prince Edward Island from 1880 to 1984. The oyster enhancement program began in 1972 and has continued through 1989. (Source: Canada Department of Fisheries and Oceans.)

Hard Clam

Some attempts have been made to increase hard clam abundance by controlling predators in local, limited areas using poisons, stone aggregate, and screens. The poison experiments involved two experimental plots on Long Island, N.Y., during the early 1960's; the beds were 6 and 8 acres in size. Both were treated with Polystream to control oyster drills which had been destroying most oysters planted on them. The treatments also killed mud crabs (Xanthidae) and perhaps other predators of juvenile hard clams. About 2 years after treatment, the hard clams were 7 and 8 times as dense (43.5 vs. 6.5 clams/m^2, and 75.0 vs. 9.5 clams/m^2) as in untreated areas around the beds (MacKenzie, 1977c). This approach was discontinued after the use of Polystream was banned.

The stone aggregate experiments were conducted in a few states. Small hard clam seed reared in a hatchery were spread over a shallow bottom which was covered with aggregate and protected by screens; the beds were less than an acre in size. In Virginia, survival of the hard clams was about 75 percent after a few months, whereas the hard clams which were unprotected did not survive. Nearly all mortality was caused by crab predation (Castagna and Kraeuter, 1977).

Table 5.—Positive and limiting features and recommended remedies for oyster reefs in Mississippi Sound.

Positive features
1. High oyster productivity: Ample annual setting, growth to market size in 2 years, and high survival on reefs having salinities between 7 and 15 ppt.
2. Adequate salinity over large areas which excluded most predators and microbial diseases.
3. Good hard bottom.
4. Quantities of shells were available under several major reefs.
5. Large stocks of oysters of all sizes were available for transplanting in polluted waters.

Name of reef	Limiting features	Recommended remedy
Tonging Reef	1. Shells too small. 2. Crab predation.	1. Spread oysters available in Biloxi and Pascagoula over reef.[1]
Henderson Pt.	1. Mud cover on reef. 2. Crab predation.	1. Remove mud with pressure board.[2]
Pass Marianne, Telegraph Key, and Merrill Coquille Reefs	1. Only a quarter as many shells on reef as needed. 2. Crab predation.	1. Tow rigid long-tine cultivator over reef to raise buried shells to surface.

[1]Method was implemented briefly.
[2]Method was tested.

Soft Clam

Soft clam abundances have been substantially increased in experimental and small commercial beds in Maine and Massachusetts by using fences to exclude green crabs, *Carcinus maenas*. Soft clam densities became many times higher inside than outside fenced areas during summer (Turner, 1950; Smith and Chin, 1953; Glude, 1955; Smith et al., 1955; Hanks, 1963).

Bay Scallop

Only one known attempt has been made to increase the abundance of the bay scallop through environmental improvement, and it occurred in Anthier's Pond, Martha's Vineyard, Mass., in the early 1970's. Bay scallops were relatively scarce over a section of the pond because the water was too shallow. The town dug a channel through the scallop bed 2 m deep. In subsequent years, the bay scallops were relatively abundant in the channel as compared with the remainder of the bed. Although other options were available, the town chose the scallop bed as the site to take the sand for beach enlargement in an attempt to increase bay scallop production.

The Need for Shellfish Production Specialists

Coastal states, counties, local communities and shellfishing companies need the services of an expert in shellfish management to help enhance their shellfisheries. This shellfish production specialist would make in-depth studies of the practical problems of shellfisheries and, with the involvement of local fishermen, lay people, fishery administrators, and politicians, develop solutions for them. The emphasis would be on increasing shellfish abundance and yields for both fishermen and consumers.

Edwards (1981) has discussed the need for managers, in addition to the scientists who already exist, in the fisheries field, and there are no gender limitations; in this guide, "he" or "they" refers to either sex in this regard. Shellfish production specialists would be hired by coastal states, counties, or towns to enhance their shellfisheries. This guide will also be usable by marine extension agents in the Sea Grant Extension Service (NOAA Sea Grant Program).

Required Experience

A good background for shellfish production specialists would be a coastal upbringing. They would know how the fishermen and local people think and feel about their working life, and they would speak their "language." Moreover, they would have a strong incentive to enhance shellfisheries, and they would not have any bias against applied research and development or shellfish that have economic importance. Also, they would be adept at solving practical problems, working on commercial shellfish beds, and cooperating with fishermen. They would have a feel for working with nature, i.e., being able to predict the consequences of an environmental change on shellfish abundance. Someone with a background in sociology and shellfish biology would also be effective. A specialist should be a professional who can make mature recommendations for increasing shellfish abundance and the earnings of fishermen. He must be capable of identifying limiting factors in beds, conducting field experiments, and developing technologies that work and are profitable for the community to apply.

Ideally, a specialist should have some academic coursework or training, or at least have done extensive reading, in wildlife or agricultural management. In wildlife courses, the student learns how to manage wild animals by manipulating environments. For species after species, the student learns: 1) Environmental requirements, 2) ideal habitats, and 3) examples of how manipulated environments have affected abundances of wild animals. He can easily apply these principles to shellfish management. He also becomes aware of the social and economic factors which influence programs. Anthropology courses, which examine fishermen's behavior and describe interviewing techniques, and a course in invertebrate zoology are recommended.

A specialist must have confidence in himself to be able to impart new knowledge and useful suggestions to fishermen and, after making his surveys, to recommend and implement technologies on beds. It requires experience, however, to make recommendations which can be implemented and work successfully. A specialist will be more likely to succeed if he has had or shared with another preson, the experience of: 1) Having an idea for development, 2) selling it to others to gain support, 3) developing it into something tangible, 4) implementing it in practice, and 5) dealing with it after it becomes established. A specialist with little experience would be at a disadvantage. To carry out the work, he would have to proceed with caution.

Required Attitudes

Most of the problems that a specialist will encounter deal with human af-

fairs. His work, if successful, will affect people positively. Lilienthal (1967) wrote that the role of the manager has been neglected. He said that while industries and government agencies develop the technical means to meet the world's needs, the function of the managers who would translate these means into use is not well understood. The problems which managers face are largely human, rather than technical. Since managers are usually trained in only the technical aspects, they usually fail to achieve tangible improvements in people's lives. To succeed, managers must also have the capacity to understand individuals, learning their motivations, fears, hopes, and what they love and hate, and make use of this understanding when trying to apply technical knowledge.

Personal Characteristics Required

Here is a list of suggestions written for agricultural consultants and extension agents by Sayville (1965), which I believe useful, as modified, for guiding a shellfish production specialist:

1) The secret of success in all advisory work lies in the method of approach to the problems of the fishermen, his family, and the community. A specialist must have those characteristics and aptitudes which will win respect and friendship of the people with whom he works.

2) A specialist must be approachable. He must also know how to approach people and be willing to be approached at any time of the day or night. An effective specialist does not know the meaning of "office" hours; much of his effectiveness is achieved after the normal day's work, and fishermen and their wives feel free to discuss personal and community problems.

3) A specialist should have patience. He must be tireless in explaining actions to improve the beds and other aspects of the fishery. During interviews, he makes suggestions instead of issuing instructions. He cultivates people's minds, implants ideas, and helps these develop into decisions. He should be aware that real progress always seems slow, tedious, and difficult. For example, slow progress was made in the development of methods to increase abundance of world food crops before World War II, despite considerable effort. Thus the specialist must never lose patience or try to implement ideas before necessary preparations are made; hasty actions may lead to catastrophe. Timmer (1982) has stated: "Reform programs that lack patience and are based upon superficial imitations will lead to nothing more but the disruption of rural life."

4) A specialist should know his job. He has to be an accomplished shellfish ecologist and technologist, who gets to know the fishery at least as well as the fishermen. In a new geographic region, he can work for a few hours at some of the fishermen's activities, such as tonging and culling, to gain an appreciation of what fishermen face. A specialist without sound practical knowledge of fishing gear and fishermen's lives is a hazard to fishermen, the local community, and the department for which he is working. He cannot afford to make many technical mistakes and, therefore, he must be careful to learn all he can, quick to learn what is correct, and confident in his ability to say and do what he knows to be reliable.

5) Good communication skills are recommended. Much of what a specialist needs to learn to be successful will be obtained from interviews, listening earnestly to what others have to say.

Schofield (1979) lists some behaviors which extension agents should avoid:

1) Local values and norms are often ignored by outsiders coming into a community, who egotistically assume that their aims and means are convergent with those of the society which they are attempting to improve; they fail, therefore, to understand the cultural system upon which they are imposing. In particular, local beliefs are often dismissed as irrational superstitions.

2) If a specialist behaves outside of community norms, he will either be humorous to local people or cause them to worry and will certainly constrain the acceptance of programs based on community cooperation.

3) A specialist should conform to community values and not run programs mainly for the benefit of the fishery agency or use projects and funds for his own ends.

4) The behavior of a specialist should not be patronizing of people in the community. Cooperation is not fostered by such an attitude.

I would also add that every act of a specialist, indeed every word uttered, has the potential to enhance or impede the work, or to confuse the people to be affected. Thus everything a specialist does and says should be considered ahead of time.

Roles of a Shellfish Production Specialist

In developing a shellfish enhancement program for a community or agency, a specialist will have five roles: Practical ecologist, educator, developer of tactics and technologies, coordinator, and mediator.

Practical Ecologist

Dasmann's (1981) description of the role of a wildlife manager well describes a specialist's role as a practical ecologist. The reader should substitute the word "specialist" for "manager" and "shellfish" for "wildlife". He states: "The manager. . .must search through the range of limiting factors, seeking that which can be most practically and economically remedied. Habitat research and management have sometimes been defined as attempts to discover limiting factors and then to remove each in turn until the maximum feasible production of wildlife is obtained."

To accomplish the above, a specialist may have to examine the shellfish habitats with scuba. A remote TV/video camera and monitor and a submersible vehicle might be substituted for scuba in relatively clear water. Environmental deficiencies and potentials for increasing shellfish abundance in beds would be determined only with difficulty and great uncertainty without such visual observations.

Probably, oyster production would not have declined nearly as much in the United States at the beginning of the 20th century had scuba then been available to shellfish biologists, and if it had been used more frequently when it be-

came available later. Biologists would have observed how the oyster's environment was degrading and may have taken the steps necessary to maintain or improve its quality. Instead, the environment steadily degraded in ways that were then not realized. Moreover, the means could have been found to improve the environments of hard clams, soft clams, and bay scallops, thus enhancing their abundances as well.

Educator

Education of fishermen, "local" citizens, fishery administrators, and politicians is an essential aspect of an assignment. A specialist provides local people with a vision of the shellfishery at an elevated state and with a clear understanding of the process for reaching it. Education must be conveyed verbally and through progress reports.

Developer of Tactics and Technologies

As the limiting factors of shellfish abundance are identified, a specialist would try to devise technologies to control at least one or two of the major factors. He can search through the literature for technologies which do a similar job, and, if found, judge whether they would work, perhaps with modification, on the local beds. If not, the technologies would have to be developed.

Some traditional methods of handling shellfish by fishermen might not be adequate if production from the beds increases. Thus while new methods are being developed to increase shellfish abundance on the beds, new methods may be needed for increasing the efficiency of gathering, handling and marketing shellfish.

Coordinator

A specialist has to understand the "big picture" of the shellfishing industry, which ranges from identification of limiting factors in the beds to marketing. In other words, he has to know the factors needed to bring about an increase in production and expansion of markets. In his role as a coordinator, he sees to it that all connections are made in the right place and at the right time, makes sure that all needed materials are available when required, and becomes involved in market promotion.

Mediator

A specialist will have the role as mediator between fishermen and fishery administrators as well as among fishermen. Communication between the fishermen and public officials is commonly poor. Before any formal meetings concerning shellfishery matters are to take place, the specialist should discuss one or two of the central issues with the administrators to determine what they want and believe they can accomplish. He then advises the fishermen about what he heard from the administrators and tries to get a consensus of views from them about the issues. Afterwards, he should discuss the fishermen's views with the administrators. Before a meeting, he advises both groups about what to say to the other during the meeting. The result might be that effective decisions could be made on the important issues, resulting in productive action.

Often, fishermen have good ideas about how the management of public beds could be improved. However, they have difficulty talking these over amongst themselves, agreeing on one or two workable ideas, and then presenting them properly to administrators. This can be one of the most productive aspects of a specialist's work. He visits nearly all fishermen on an individual basis, discussing with each a new management idea and how they believe it can be developed and implemented to benefit all parties. He focuses the thoughts of the fishermen and keeps the proposal simple. He can anticipate that most fishermen will contribute ideas to the proposal, making it more effective and workable. Some fishermen will have to be visited more than once to discuss any changes since a previous visit. When the proposal generally satisfies the fishermen, it is presented to the administrators for their review.

The ideal is to have the specialist, fishermen, and administrators work together in developing a better management policy. Since the administrators are usually busy with other matters, however, it is best to have the specialist and fishermen develop a proposal and then take it to the administrators as outlined above. The first concern of an administrator about any new proposal is likely to be the fishermen's opinion. The success of the specialist in this role as mediator, as in his other roles, will depend on his ability to maintain a bond of trust with fishermen and administrators (Parker and King, 1987).

The Identity and Roles of Other Participants

A number of people would be involved in a shellfishery development program for public beds in addition to the shellfish production specialist. They include a fishery administrator, the specialist's associate(s), fishermen and other "local" people, public health officials, and the boat captains and crews. The only people to work full time in the program are the specialist and associate(s); after the program is implemented, the boat captains and crews would become involved. The remaining participants will be working at other positions and can devote only a small amount of time to the program. This section describes the role of each of these participants.

Fishery Administrator

An administrator of shellfish programs is an important element in the chain to ensure successful implementation and culmination of shellfish enhancement projects. He is required to provide the following:

1) Support to the shellfish production specialist. The administrator has to plan ahead and secure the funding to provide for the operation, infrastructure, and other costs associated with the program. These may be borne by the government or industry or both.

2) completion of paperwork to access funding. In any government operation there is a requirement for paperwork, often in large quantities. This load cannot be transferred to the specialist whose time has to be spent in the field. This does not mean that the specialist completes no paperwork, but it should be only the necessary forms which do not interfere with field operations.

3) Provision of rationale and justification for programs. The administrator provides the government with the justifi-

cation for the work, with relevant projections based on past programs or anticipated results. The justifications should allow for a continuance of the programs to their completion.

4) Building flexibility into programs to allow the specialist maximum maneuverability in executing them. The programs need an element of flexibility built into them. Without this, the program will not be able to respond to various localized differences during its implementation and execution.

5) "Running interference" for programs. In any program which disturbs the "status quo," there is bound to be a certain amount of complaining, criticism (just or unjust), and doubt. (Both the specialist and administrator have to handle this role.) The administrator's role is particularly important so the program will not be modified to a level where it is unproductive; the administrator has to have a firm commitment to the effort.

6) Providing future projections, on a 5- to 20-year basis, in cooperation with the specialist (depending on the scope of the program). The administrator must make clear that shellfishery enhancement must, by its very nature, be conducted over a 5- to 20-year cycle. The first 5 years will be a period of change, adaptation, and acceptance by the industry. The second 5 years provides a period where monitoring and some increases in production will take place, with the remaining years looked upon as an expansion to reach the desired level of production. In small communities without such an administrator, politicians will act in this role.

In most instances, the fishery administrator will be the person who hires the specialist. Wise administrators will hire an accomplished, experienced specialist and then advise him that shellfish production has fallen sharply and that they have hired him to show the community how to return it to or above previous levels of production. They will also provide him with a modest amount of capital for making tests and developing technologies.

The position of shellfish production specialist outlined in this guide is a very responsible one. Thus the salary should be relatively high. It should also be high enough that the specialist is not always looking for another job. The specialist should report to the fishery administrator or other manager, rather than to a scientist, because managers want production to increase. The specialist should be given some independence and some authority so his work will get credit for production increases.

Associate Production Specialist(s)

These are associates to a specialist in all roles, including being a safety buddy-diver. Ideally, they should be from the local community so they can inform the specialist about local affairs. They should learn enough from the specialist to be able to run the program and develop it further if the specialist should depart. The rules and guideines presented above for the specialist also apply to associate production specialists.

Fishermen, Processors, and "Local" People

These people have the responsibility of supplying information to a specialist about fishery operations, fishery history, bed locations, and changes in the estuaries, as well as ideas for development. The information is passed along during informal conversations. Ultimately, they also have to judge whether a program should be implemented on their shellfish beds.

Public Health Officials

The responsibility to ensure that shellfish purchased by consumers is not polluted, i.e., (is safe to eat) is vested in public health officials. They must advise the shellfish production specialist about the location of the polluted beds.

Boat Captains and Crews

This is the group which actually improves the beds. Collectively, they bring their knowledge of boat handling and gear to the job. A first-class captain can at least double the output of a mediocre captain.

The Power, Incentives and Risks of the Participants

In a public fishery, the power, incentives, and risks among the various people involved are different than they are in a private company. First, a definition of "power": It is the ability to make decisions, to take risks, to lead, to get things done. Without such power, nothing happens; there is stagnation. In a private oyster company, management is interested in profits, and it can direct specific actions for personnel under its employ to be followed to ensure that profits are made. The workers in a company are under pressure from management to complete specific jobs. Management has total power to direct actions and it, alone, takes risks. If management uses advice from a shellfish production specialist, it will anticipate an increase in company profits. In most cases, a manager will profit financially and thus will have great incentive to increase shellfish production.

Where does power lie, what are the incentives, and what are the risks to the participants involved in a program to develop shellfish culture in public beds? In public shellfisheries, the people to receive tangible profits from an increased shellfish supply in the beds are: 1) The fishermen and, somewhat less, the local people, and 2) the wholesale, retail, and distribution people, as well as the consumers of shellfish who will have more (and perhaps less expensive) shellfish available to purchase. Of this group, only the fishermen will be considered in this section. The power, incentives, and risks that each of the participants is likely to have are described below.

Specialist and Associate(s)

Power

In some circumstances, the person with knowledge is the one having some power. The specialist will determine the limiting factors of shellfish abundance in the beds. He will try to learn how to control at least one or two factors via cost-effective means. When such knowledge is attained, it might appear that he would have some power. Often, however, he does not have the power to make decisions about funding and implementing the program; politicians, fishery administrators, fishermen, and local people usually have that power. A specialist can tell these people what the problem

is, what caused it, how it was caused, and how to solve it. But the others decide where, when, and usually whether to solve it.

Incentives

If a program succeeds, a specialist will not gain monetarily; he does gain in self-esteem, however, from achievement in a difficult task, and he will feel that he has contributed to the betterment of a societal group. Moreover, he may gain a measure of recognition and prestige locally.

Risk

A major problem facing a specialist will be that his knowledge and experience may not always be adequate and thus some uncertainty about the success of a project will exist. The development process is often only partially subject to human control; variable extremes of weather and other conditions may prevent a shellfish set or kill seed. When implementing a program, a specialist risks his reputation and esteem. His reputation is in jeopardy if the program is a failure because he may lose the trust of the community regarding his ability and judgment thereafter. The situation is analogous to a medical doctor who examines a patient and reports him in good health; if the patient dies soon afterward, the doctor's reputation may then be severely damaged. In addition, a specialist could "lose face," be embarrassed, and appear diminished to people of the community.

Fishery Administrator and Politicians

Power

A program can be implemented and function only if officials legislate it and supply the money for it. Moreover, the key to successful continuance of a program is the degree to which the administrative and political leadership is willing to cooperate and is ready to use the instruments of government to attain its goal.

Incentive

Administrators and politicians would have a strong incentive to back a program which promised to improve the conditions of people's lives by raising employment and prosperity within their community. They do not gain monetarily in a direct way. A successful program provides administrators and politicians with a sense of accomplishment, and it might help politicians become reelected.

Risk

Usually, politicians require that programs which they sponsor have popular appeal. Otherwise, they fear a backlash from the voters. The implementation of a program which results in substantial damage to the fishery or leads to reduced employment and income presents a risk for politicians because it threatens their image, effectiveness, and job security.

Fishermen, Processors, and "Local" People

Power

Because the beds belong to these people, they have the power to control the direction of projects within a program and, if they wish, stop implementation. Usually a relatively large group, fishermen and local people have had substantial influence on political decisions; politicians will never allow implementation of a program if mass opposition to it exists.

Incentive

Fishermen, processors, and local people have great incentive to support a sound program because they will profit substantially from it in the future.

Risk

When a specialist enters the scene, a shellfishery may be extremely depressed financially. If a program is to be developed and implemented, the fishermen and local people will be facing several risks. One is that operations on the beds may kill some shellfish or damage their habitat; if so, the shellfish abundance may decrease and incomes of the fishermen and processors will fall further. A second risk, often greater, is the possible loss of money invested in construction of equipment and hiring boats, captains, and crews. There is also the risk that increased supply will exceed market demand and the price will drop. Thus net income from the enhancement may not change much.

Public Health Officials

Power

Public health officials have the power to modify a program substantially if an aspect of it involves polluted shellfish; they will not allow polluted shellfish on the market.

Incentive

From the standpoint of their position, public health officials would have an incentive to back a program which produced more shellfish on unpolluted beds, because the fishermen would then have less incentive to poach shellfish on polluted beds, thus making the public health officials' job easier.

Risk

Public health officials are under a large risk if the program is to involve the handling and transport of polluted shellfish. They would expect that the program would guarantee that no polluted shellfish finds its way to the market. If the officials could not protect the public from eating polluted shellfish, they could lose their jobs or prestige.

Boat Captains and Crews

Power

This group has limited power to modify a program, although as former or experienced fishermen, they have local knowledge and thus some power if consulted.

Incentive

In most instances, boat captains will be former fishermen who lived through periods of low shellfish supply; they would view their job as an opportunity to increase shellfish abundance on the local beds. Thus, at least initially, they would have high incentive to do a good job and work hard. On the other hand, a captain would be under much less pressure to produce under lax supervision of a local official than he would under a company manager. With some individuals, the incentive may gradually

wear off when 1) they discover that their pay is level (i.e., their pay is the same whether or not they work hard) and 2) their efforts are criticized by some fishermen. No program will be perfect, and thus the usual critics will "sound off" when small errors are made. The boat captains and crews may be the ones to hear most of the criticism, and they will have to defend the program.

Risk

Boat captains and crews risk their reputations and those of the local government and the specialist if they do a poor job of executing the program; they could also lose their contract to work in the program, and their vessel(s) could be damaged.

In summary, it can be seen that: 1) A specialist, administrators, and politicians, as well as fishermen and local people have certain powers to implement or block a shellfish enhancement program: 2) a specialist, administrators, and politicians have much weaker incentives to implement a program than does the manager of a private company. If it succeeds, their self esteem and pride in their job increases, but they may not gain monetarily; and 3) the fishermen and local people risk financial loses, and a specialist, administrators, politicians, and the boat captains and crews risk tarnishing their reputations if the program proves to be unsound or if it were conducted poorly and resulted in reduced shellfish abundance. A person does not want to risk tarnishing his reputation by lending his name in support of a project or program which, later on, other people say was a waste of money and time.

A shellfishery enhancement program is most likely to succeed if specialists, administrators, politicians, and boat captains and crews are experienced professionals, have sufficient incentives, a willingness to make sacrifices for the cause, and they work well together. If participants do not all work toward the goal of enhancing the shellfishery, a program is not likely to be successful.

Some Important Aspects of a Shellfish Production Specialist's Assignment

Economic development is difficult. It is no easy task to improve the economy of a shellfishing community—to create more jobs and produce higher wages—and produce more shellfish for consumers. Because the role of a shellfish production specialist will be new in most localities, there will be no systems in place to accomplish the required tasks. To an extent, the specialist may have to depend on some of the people doing things "out of the goodness of their hearts." Moreover, the interactions which he will have with other people will all be new; people will not be used to dealing with someone in his role. Thus, all tasks may seem to be uphill and require more work than might have been anticipated. The goal of increasing and stabilizing the shellfish yield is maintained during all the work. A specialist must not leave the track leading to that goal no matter how strong the temptations.

A specialist should be aware that the community will hold many beliefs, customs, and expectations, some of which will be unique to it. It will have had a long history of interrelationships based on the ups and downs of its shellfishery. He should also be aware that his work will impinge upon a complex network of subtle human relationships. The prestige and influence of various people in the community and fishery vary considerably. A specialist has to learn about the intricacies of community life and individual personalities if he is to succeed; statements and actions which are at cross purposes to beliefs, customs, and expectations of the community or its leading citizens or fishermen, or which are disrespectful of local taboos can severely taint local attitudes towards a specialist and his proposals. The specialist should learn the names of local people, places, fishing grounds, and gear, and pronounce them properly. He should be aware that people with strong egos will try to influence his work, and he has to be prepared to deal with them.

A specialist should also be aware that he will be trying to aid a shellfishery which may have been functioning for many years. From humble beginnings, it has become a locally important business. The fishermen have developed boats, gear, and methods, and they have acquired knowledge to gather shellfish in quantities which are sufficiently large to make it profitable to do so. Processing (packing) plants may have been developed to handle quantities of shellfish at a profit. Refrigerator trucks have been purchased to preserve the quality of shellfish and distribute them reasonably promptly at a profit. Associated wholesalers and retailers may have developed methods for handling a certain volume and quality of shellfish and selling it at a profit. Consumers accept certain shellfish products as part of their diet. Everyone connected with the shellfishery has tried to increase the efficiency of operations to increase profits. It has been a business of tight economics and small profit margins within each component. Thus, a specialist is not likely to be able to find large deficiencies which he can improve in the shellfish production and marketing system. Probably, an increase in efficiency would require the introduction of better gathering gear, shucking machines, and perhaps new packaging. Equipment should be improved only after abundance is increased and a careful analysis of the shellfishery is made to be sure that improvements are needed and will not have a negative effect.

The state or local community legally owns the shellfish beds, but a specialist should instead view the situation in terms of the fishermen and local community owning them. Moreover, the fishermen and community should be considered as analogous to a farmer who owns his land, and they should be treated as the farmer would want to be. Thus, the fishermen should be shown a new approach and then be asked whether it should be implemented.

Improvements and new concepts and technologies will generally come from above, but they should take much of their direction from below. Thus, the work of a specialist should begin at the roots and go upward. The fundamental basis lies in 1) the condition of the beds which must allow efficient settlement of larvae and good survival of seed shellfish and 2) the working life of the fishermen. A specialist should not approach his assignment with a preconceived notion of what he and the administrators believe is good for the shellfishery, introduce methods and ideas from some-

where else, and then try to force them into practice. If a specialist ignores the roots, little chance will exist that success will be achieved.

Moreover, technologies and programs should be designed or modified to comply with fishermen's desires. Most strategies proposed in the literature have represented a "top to bottom" approach and have not been implemented.

In developing a new technology and program for people to use, many planners are guided by the "5:95 rule." Its definition is as follows: The physical aspects of designing and testing prototypes and constructing a workable technology will consume only about 5 percent of the effort, while the aspects of dealing with the related human factors will take 95 percent; thus the designing and construction of a potentially beneficial technology are relatively easy when compared with the human factors related to its application. The rule also applies when designing a better management plan for public beds.

The environments of beds of particular shellfish species can vary somewhat from one another. Thus, a specialist will have to increase shellfish abundance on a bed-by-bed basis; each bed will have to be examined separately, its deficiencies diagnosed, and then, possibly, a unique remedy developed to correct them.

A specialist will soon discover that many preconceived ideas exist for developing the shellfishery. They will come from fishermen, processors, "local" people, local scientists, and administrators. Moreover, new ideas and old ones will keep coming to the forefront in quantity. The specialist will have to select those ideas useful for the enhancement of the shellfishery and maintain control over them. He will have to explain to others that he believes it important to do so and, eventually, through constant endorsement sell the concepts to the locals. A development program has to be long term. A one-season "miracle" cure will not work.

The Conduct of a Shellfish Production Specialist on an Assignment

This section lists the initial steps which a shellfish production specialist can take in a shellfishery enhancement assignment. The broad-based approach which a specialist may follow is described next. The remainder of the section consists of a list of guidelines for conducting the assignment.

Initial Steps

The first step which a specialist takes is to gain an understanding of the objectives of the assignment from his superiors and to tentatively agree on what they believe will be attainable goals. The need to identify objectives cannot be overstressed. At the beginning, however, most problems are likely to be ill-defined, and also it is likely that no one will know precisely how development will proceed. A specialist should periodically discuss progress in the program with the fishery administrators and politicians. These authorities need to know the projected costs of a program on public beds, and a specialist needs to know how much money is available to spend. The authorities will also want to know how popular the program will prove to be in the community.

The second step is to spend the necessary time examining selected shellfish beds with scuba gear. A specialist and his associate(s) can thus get a general idea of how the beds appear and perhaps can get some good clues about limiting factors which exist.

The specialist then meets with leaders in the fishery (i.e., the leading fishermen and packing house processors) to present an overview of what he will attempt to accomplish. Likely, they will want to know the answers to a number of questions: 1) Can the beds be cultured to yield more shellfish? 2) If so, how much more? 3) How can it be accomplished? 4) How long will it take? And, 5) will the beds be safeguarded from damage?

Undoubtedly, a specialist will be under pressure to improve the shellfishery quickly. He should try to give some indication of when and how much shellfish production will increase, not promising more than can be delivered. In a short-term assignment, a specialist should have knowledge available or, alternatively, a technology which he can try to accommodate to local use to increase shellfish abundance or to help fishermen become more productive. An article or news release should be prepared for the local newspaper to announce that a shellfish development program is underway; this will alert them that a specialist has been hired and will raise the mood of the fishermen and community.

A specialist garners all the information about the industry which fishermen have, adds it to his own, and with the observations about limiting factors which he has made in surveys of the beds, begins to apply the collective knowledge. Then, to control the limiting factors, he devises technologies whose use is compatible with the community and inexpensive enough for communities to afford. A shellfishery development program is then drawn up and implemented; eventual feedback enables evaluation of its success and application to future projects.

A specialist should be aware that no progress will be made unless he supplies the correct information and technologies. He will not succeed if he only urges fishermen to develop better technologies, advises them to cultivate rather than "mine" the beds, or advises the local administrators or politicians to develop a shellfishery program by themselves.

Use the Broad-based Approach

The broad-based approach assumes that: 1) Fishermen and local people have the right to be involved in decisions made about managing public beds; 2) these people have a great deal of knowledge and good ideas, and thus the development of a technology and program to enhance the shellfishery will be much better designed when these people contribute ideas to it (a workable program could not be formulated otherwise); 3) support for a program will be much stronger; and 4) the connections between various people, events, and actions will line up properly, and thus the development program will more likely be successful.

The approach involves discussing every reasonable idea for technologies to be used on the beds or management with anyone in the community who

might have information or an intelligent opinion about them. The various people with whom knowledge is shared include especially the fishermen, but also those involved with processing, wholesaling, lawmaking and enforcement, and public health. Knowledgeable persons also include fishery administrators and politicians, the blacksmith who will construct any new gear, boat captains and their crews, and interested lay people. A specialist should ask opinions of friends, neutrals, and enemies. When using this approach, those typically uninvolved become involved, issues otherwise ignored are identified and assessed, and involvement becomes focused and issue centered (Preister, 1987).

A specialist must take the time to listen to a large cross section of fishermen and others so as to gain a clear understanding of what they know, what they need, and what improvements they may suggest. He must also try to increase the knowledge of fishermen and local people, especially about limiting factors in the beds, as he gathers data during his field and laboratory studies. Interviewing and sharing ideas with these people increases their interest and gives them a feeling of involvement in development of their industry. A specialist will also have to learn people's strengths and weaknesses and what their thinking patterns are like. Critical factors, such as personal needs, motivations, and limitations, often defy logic and have to be studied and understood, sometimes intuitively. A specialist should welcome constructive criticism and advice.

A specialist should work one-on-one with individual fishermen and processors to find out what they know, want, and feel. If fishermen are approached properly with a sincere, interested, respectful attitude by the specialist who uses a flexible, open-ended mode of questioning, they will open up and offer information that goes beyond specific questions being asked, as recommended for obtaining information from rural people by Green (1987). Usually, fishermen do not resist answering questions, because they enjoy talking about shellfishing.

A bonus from such meetings is that loose ends within the fishery can be tied together for increasing efficiency where lines of communication are normally absent. For example, a specialist can survey the best equipment and techniques employed by various processors, and then, if it can be done without creating conflicts, make them known to all groups. The tying together of loose ends and making the best equipment universally known are inexpensive ways to upgrade a shellfishery.

During the early interviews, it will become apparent that people have divergent views about what ails the shellfishery and how to improve it. Logical sounding views need to be recorded for possible later use.

In a public shellfishery, the fishermen can be interviewed on the water, at the docks, in their homes, or at meetings. Processors can be interviewed in their offices. Personal visits afford opportunities for: 1) Gaining insight into the lives, outlook, and culture of the fishing community, and 2) discovering the local leaders of public opinion and the fishermen who are progressive in outlook, besides learning a considerable amount about shellfishing. During interviews a specialist should develop a climate of trust with the local people ("if you do not trick me, I will not trick you"), and establish that his objective is service to the local community, not his personal gain.

Initiating discussions with some of the fishermen may be difficult. They may be skeptical of a specialist's worth, perhaps having already heard promises by biologists which were unmet. A specialist should be aware that fishermen are rather cautious and defensive because they can afford little risk. Some may speak with anger and passion, leaving no doubt that shellfish abundance is a matter having great importance.

An effect procedure for opening discussions with fishermen is to ask a series of questions such as:

What are the needs of the shellfishery?

What do you believe should be done to improve it?

We are thinking about doing... (give examples). How do you think they would work?

What do you suppose would happen if we did (give example)?

Do you believe that gear having this design (show a drawing) would work?

Would you benefit if shellfish abundance were increased?

Who would purchase the shellfish which you gathered?

Usually, fishermen will give expansive answers to these questions. A specialist will obtain a substantial amount of information from interviews of 10-15 fishermen. Interviewing only a couple of fishermen will not be effective.

Fishermen's wives should also be interviewed, if possible, because they will provide some new, practical, and useful perspectives about the industry. Women will also support management proposals which promise more employment and higher wages. Moreover, their influence on community public opinion can be high.

By involving the community in the planning process, there will be a continuing exercise of grassroots power, and most administrators will be pleased to follow the guidelines of the community (Turner, 1987). "Sensitivity to local interests and a professional means to accomplish (goals) can save money, improve project design, and lead to greater long-term stability" (Preister, 1987).

Guidelines

A number of guidelines are given here to help a specialist conduct his assignment.

Good Relations

A specialist has to maintain good relations with the community, fishermen and other biologists. The six points listed below will provide guidance in this regard.

1) At all times, an effective specialist should try to keep the shellfishery's problems and development ideas in the forefront, and keep himself in the background; he keeps a low profile. Doing so will help in maintaining good relations with other biologists or managers; their egos may be "bruised" if a specialist is successful in enhancing the

shellfishery. The abrasions will be much smaller if the shellfishery is kept in the foreground.

2) It is essential to make people, especially the fishermen, feel important. A specialist can help to accomplish this by listening to their ideas. If local people are made to feel important, they are more likely to support a sound developmental program. On the other hand, if they are ignored, especially when they feel strongly about the industry, they may become an enemy of the program. A specialist should consider himself an associate of the fishermen and avoid a tone of knowing superiority.

3) The fishermen should be given some information in trade for their time when they provide assistance or information. For example, a specialist can describe the observations which he makes while diving on the beds.

4) When samples of shellfish are taken ashore for examination, they should be returned to the beds afterwards; no such shellfish in quantity should be allowed to die. A specialist might also remove some predators, such as starfish, which he sees on the beds while making surveys.

5) When encountering resistance from an individual or a small group regarding a proposed action, a specialist should first find out why and then respond tactfully using the manner in which an expert politician responds. A politician side-steps sensitive issues or faces them obliquely, in an attempt to diffuse them. He hopes that if they are ever raised again, the opposition will have lost interest in them or the overall situation may have changed and the issues will seem unimportant. If the issue is faced head-on, however, the opposition will likely become stronger and a battle of wills between a specialist and the opposition will follow. The result may be that the action will have to be permanently shelved and a specialist may have wasted too much time and energy in the battle, besides reinforcing animosity towards him.

6) Sometimes, fishermen criticize the local fisheries agency or laboratory for a lack of tangible results. A specialist can defend these entities without antagonizing the fishermen. Nearly always, fishermen have misunderstood the objectives of the agency or laboratory and these can be explained with patience. On the other hand, fishermen should never be abused for criticizing a public agency or laboratory or for not using a recommended method.

Develop Credibility

Credibility of a specialist's word must be developed. Ultimately, the fishermen may have to depend on the specialist's word for certain critical knowledge. Thus during interviews and in reports, a specialist relates only facts; if guesses or estimates have to be made, they should be clearly identified as such. Periodically, the fishermen may test a specialist's knowledge to determine his reliability. If any substantial weaknesses are detected, the fishermen will not have confidence in a specialist to follow his advice.

Work Performance

A specialist and his associate(s) do the brunt of the work. Everyone else involved in the program will be only peripherally involved and will not have time to do much work on it. Thus the fishermen and local people cannot be expected to become involved in testing technologies or gathering data from test plots. The administrators and politicians should not have to spend time resolving conflicts between groups. A program will not be developed if a specialist tries to assign such work to others. When various groups are asked to support the implementation of a technology or program, they only should have to review the data which a specialist has gathered. The relationship between these groups and the specialist in this regard should be as follows:

1) Fishermen and local people: They supply background information; a specialist finds and supplies answers to their questions.

2) Fishery administrators and politicians: They support program development and allocate funds, but a specialist fills in the unknowns and handles conflicts himself.

3) Blacksmith: He brings his knowledge of construction to the job, whereas a specialist gives him the design of equipment to be built.

4) Boat captains and crews: They bring their knowledge of operating boats and using gear to the job, but a specialist may have train them or work with them to operate any new equipment.

Objectivity

A specialist begins with an objective view of the shellfishery, i.e., without any preconceived notions. At the beginning, he makes his own observations and then follows the directions which he believes are best. He does not initiate the assignment by gathering together all available verbal and written information and then following the suggestions which they recommend. Probably, he will be asked to develop a shellfishery in which other biologists and managers have already made studies and suggested improvements. The fact that he was hired probably means that any earlier suggestions did not improve the fishery substantially. For at least a few months, a specialist should not interview other shellfish biologists in the area, because they might lead him astray. Such interviews should be held eventually, however, because it is likely that much useful information will be obtained; during these interviews, a specialist can sort out the useful from the nonuseful information.

Responsibility to the People

After his responsibilities to the agency which has hired him, the fundamental responsibility of a specialist is to the people: Fishermen, local people in communities and consumers; moreover, the centerpiece of concern is the fishermen. It follows that the local community will benefit economically and consumers will have larger, less expensive shellfish supplies, if the incomes and employment security of individual fishermen can be raised through an increase in shellfish abundance and production. A specialist should be aware that the key to winning local support is to develop a program which promises increased local earnings. Thus he should give highest priority to projects whose payoff will raise or stabilize incomes.

Identify Community Values

The needs and social values of the community have to be identified through penetrative probing. A specialist has to be sure that the results of his work will meet needs and comply with values. He should not assume that he knows what the needs are ahead of time. A specialist selects beds and projects which people care most about. Usually, these will be the best from an efficiency or cost-effectiveness viewpoint but not necessarily.

Projects should begin where the needs are: The most productive approach is to develop methods which meet the immediate needs of the fishermen, i.e., improve their material welfare. If presented with a choice of two good methods, a specialist selects the one which people most desire. In order that the various components within the shellfishery might use his recommendations, a specialist should be guided by the fundamental principal of marketing goods: Find out what people need and want and then try to give it to them.

Identify Local Problems

Somewhat related to the previous guideline, a specialist makes sure that he correctly identifies the problems which the local people have. He does not want to waste effort trying to solve a problem whose solution has no value. Solving problems whose solutions have no use or value is a common human endeavor.

Some communities may have limits on how much an aquatic environment can be modified to increase the abundance of shellfish. Certainly, communities which are partially supported by a fishery for the blue crab, *Callinectes sapidus*, will not allow it to be killed, and there are state regulations to be taken into account.

Get Involved Locally

A specialist must spend most of his time living with the problems. He should remain close to the shellfish beds and the fishermen and processors, to gain an appreciation of their working situation. He tries to immerse himself in the local setting, engages in local routines and attempts to experience events as a fisherman would. The information obtained from fishermen about shellfish distribution and factors that limit abundance is used to make any surveys more efficiently.

Any time that is available between making observations and interviews can be used to gather data for developing a statistical profile of the shellfishery. The available time can also be used to test or check the value of any new methods that were recommended to the fishery during the previous 10 years or so before a specialist arrived on the scene. Such tests spare the fishermen the time and cost of doing it.

Examine Limiting Factors

A specialist should devote the effort which he spends on the beds to examining factors which limit shellfish abundance, and developing methods to increase it. He should not waste time studying the fecundity, longevity, anatomy, and physiology of shellfish. In addition, he should spend only a relatively small amount of time making surveys or censuses of shellfish supplies on beds. The information is needed, but the main part of the work should not be devoted to it.

Verify Results

As a general rule, the results of early tests involving the use of a technology to improve the beds should be carried to finality for statistical verification. If time is lacking, however, the results can be inspected visually and be confirmed later when tests are repeated on increasingly larger plots. As the work proceeds, however, thoroughness and attention to details are essential. No loose details about critical aspects are left to guesswork; all details are nailed down with documented studies.

Achieving Results

A specialist uses the most expedient means possible to achieve the desired result. The objective is to achieve goals with a minimum of cost, i.e., by the simpliest, cheapest means possible. He should not fall into the trap of designing something new or extra-complicated to impress colleagues.

Compromise

A specialist should be prepared to make compromises. He might have to go along with a project which an administrator wants, to obtain his support for conducting the projects which he wants. He should also conduct some small projects which the fishermen want, so they will support his larger project(s). Hopefully, after a while, the fishermen will see that his large project(s) are the best ones.

Keep Records

A specialist should maintain records of what he does. Later reviews of the records will help him to determine why some things went right and why others went wrong.

Monitoring Beds

A specialist could probably keep track of 30-60 shellfish beds. The number of beds which he could evaluate would depend on how rapidly they are changing and their size. The evaluations would require scuba or video camera examinations of each.

Keep Costs Low

The cost of the program which a specialist establishes should be low in relation to benefits. Moreover, an enhancement program should produce shellfish cheaply, because the shellfish produced will compete for the consumer's money with other foods. The producers of other foods are consistently trying to cut production costs to increase sales. If shellfish production costs are high, sales volumes will be relatively low.

Ethics

The question of ethics is involved when a specialist works with private companies. A specialist should be aware that he works in the public interest, which is best served by working with progressive people. A progressive oyster company, however, works with a specialist out of enlightened self-interest. The company and general public benefit if a specialist helps the company produce more shellfish, stabilize production, or produce them at lower cost. A specialist should make any designs of

improved technologies or procedures which he has helped develop in cooperating with a company immediately available to all other companies and to fishermen on public beds.

Producing an Information Base

Two types of surveys—a reconnaissance survey, which provides background information, and an intensive survey, which provides specific information about the factors which govern shellfish abundance on various beds and information about the shellfishery—need to be conducted by a specialist to provide an information base. Moreover, the capacity of the local fisheries agency or its counterpart to fund a program needs to be determined. Timmer (1982) stated that a crop specialist has to know his area and know his people, asking "how can he improve something if he does not know it?"

The Reconnaissance Survey

This survey is conducted largely by interviewing local people. Descriptions of land topography and rivers, contours and depths of the bays and estuaries, and locations of shellfish beds are obtained from charts and fishermen interviews. Long-time residents can supply information about shellfishing history and changes that have taken place. Interviews of local people will provide information on the public's attitude about current shellfishing conditions, the effects of regulations, and the need for changes in regulations.

Additional information to gather includes: Statistics on historical landings, early status of the fishery when production was at its peak, and apparent reasons for declines in sizes of shellfish populations.

Early conditions of the oyster fishery are partially described in articles and books by Ingersoll (1881, 1887), Hall (1894), Stevenson (1894), Moore (1897), Zacharie (1897), Collins (1889), Belding (1912), Churchill (1920), Sweet (1941), Gunter (1952, 1953, 1975), and Rolfs (1971). Some historical information on hard clams is available in some of the sources that describe oysters and in Belding (1912). Some historical information on soft clams is available in Belding (1930), Ingersoll (1887), Turner (1949), Turner et al. (1949), Dow and Wallace (1950), Glude (1955), Landers (1954), Manning (1957), Manning and Pfitzenmeyer (1958) and Hanks (1963). Some observations on the bay scallop at the turn of the century are available in Belding (1910).

The apparent reasons for declines in sizes of shellfish populations may be difficult to ascertain, especially if they were gradual over several decades. If so, no published source or interviewee is likely to have a good perspective. Nonetheless, if the reasons can be obtained, they can be a great help in characterizing the environmental factor(s) responsible for low shellfish abundance on the beds. The best procedures to follow are: 1) Interview a number of long-time residents; usually, when several people give a similar statement, it is probably credible; 2) compare written descriptions of earlier periods with any that are available about the present period, and 3) examine with scuba where shellfish grew in the early periods and where they now grow abundantly.

The Intensive Survey

This survey is conducted largely by making studies on beds and also by interviewing. Data collection is a critical part of the work. The kinds of data collected, the way they are collected, and their timeliness may well affect the ultimate success of the work; data used to validate the program will have great impact on implementation, because validation is a measure of confidence in the results (Reisman and deKluyver, 1975). Under this survey, pilot tests are conducted to determine how much production could be increased.

Physical Conditions in Bays and Estuaries

Much of the information is probably available in the literature and on charts, which would include bottom depths. Bottom firmness, important in oyster work, can be measured by: 1) examining the bottom visually, 2) probing with a pole from a boat, or 3) spreading small quantities of oysters on test areas to determine whether they remain on the surface. The distribution of salinity, which plays a critical role in governing the growth and distributions of shellfish, diseases and predators, should be rechecked where projects are anticipated because it may have changed from earlier periods. The salinity should be measured at a series of bottom points across existing and former shellfish beds at high and low tide. The salinity will vary by season as well as by the amount of runoff, and thus these aspects will have to be considered when measuring it. Water temperatures and current strengths do not have to be measured.

Abundance, Length-frequency, and Distribution of Shellfish Stocks

Shellfish abundances can be determined by subsampling populations. A good estimate of population size can be determined by counting all shellfish within a ring which encircles about 0.25 m^2 (3 square feet), at about ten random sites in each hectare (2.5 acres) of bed. Such determinations have to be made using scuba or large grab. The counts and measurements of shellfish can be made afterwards in a boat or ashore.

Oysters and bay scallops can be collected by hand while using scuba. Abundances of hard clams can be determined by using a hydraulic suction sampler and a ring; the clams are collected in a fine-mesh bag that retains all sizes. Soft clam abundances in intertidal zones can be determined at low tide by shovelling clams within the ring into a box that has a fine screen bottom and then sieving out the clams for counting. Length-frequency distributions of shellfish can be determined by measuring about 100 specimens from a random collection.

Potential Setting Density of Shellfish in Each Bed

It is desirable to know the frequency with which the potential for commercial-level setting occurs on various beds. The knowledge will determine the risk factor, which will serve as the basis to judge whether a bed should be rehabilitated by improving the bottom for setting larvae and reducing predators or other mortality causes. If the fishermen find seed of mixed sizes in the beds, probably good setting is almost on an annual basis.

Relative setting densities of the clams and bay scallop among years can also be determined by doing extensive surveying and counting. The clam beds could be sampled frequently during the summer with a hydraulic suction sampler or a benthic grab to count the seed. The technique would work well with the soft clam which grows rapidly and can be easily separated from the sand in which it lives using a sieve with a mesh size of about 2 mm. Intertidal soft clam juveniles can be sampled by shoveling sediment into a screen.

Hard clams set at a size of only about 0.2 mm, however, and grow slowly. Thus they may remain at about the size of sand grains in which they grow for a month or more. Consequently, a sieve with a mesh size of perhaps 0.25 mm has to be used. The clams can be separated from the sand grains by elutriation (separating the clams from the sand by repeated rinsings); it takes about 2 hours to elutriate each sample and one to two hours to count the clams in it using a dissecting microscope. Scallop seed may have to be sampled among eelgrass blades. Sizes of annual scallop sets can be roughly estimated by finding out from fishermen and wardens what the landings from various beds were over a period of years. Each year's landings of scallops is comprised of one year-class.

Important Considerations in Diagnosing Limiting Factors

Studies should center on determining the condition of beds as environments for 1) setting larvae and 2) seed. Thus, the most important study period is during the summer when larvae are setting and seed are especially susceptible to predation and in the autumn when predation on seed continues.

Studies should be made on a broad, rather than a limited front, i.e., examining several, rather than only one, possible limiting factors. The advantage of doing this is that some factors may be impractical to control, whereas one or more of the others may be controlled easily and at a low cost. Moreover, the possibility increases that more than one limiting factor may be successfully relieved simultaneously; if so, an "abundance takeoff" of the shellfish as was achieved with oysters in Long Island Sound might take place.

Studies of limiting factors should be conducted on an immediate, rather than a long-term, basis. Only studies involving factors to which methods can be applied immediately, or can be developed quickly, to improve the environment should be made. Long-term studies would include life histories of predators and diseases, looking for possible weak places in their life cycles which can be attacked. The information is mostly available already from studies in other areas.

Emphasis is placed on those limiting factors which can be practically altered. For instance, temperature and salinity, which may limit shellfish productivity but are usually not controllable, are not examined in detail.

The limiting factors of shellfish setting and survival can be identified and evaluated by using the procedures described below. As noted, several scuba swims over shellfish beds during the summer and autumn might provide adequate answers. A helpful procedure is to compare the appearances of beds where shellfish are abundant and where they are scarce. For example, a specialist might be able to observe that where oysters are abundant, the beds which they occupy are covered with shells, little silt is present on the shells, and few predators are present on beds, and where oyster abundance is low, shells are scarce and silt or predators might be abundant.

Determining Substrate Condition for Setting Larvae

After making a good estimate about the factors that reduce setting densities of seed from scuba observations, identity of the factors can be confirmed by establishing several plots, each about 1 m^2 (1 $yard^2$), on the beds immediately before the setting season of the larvae (Fig. 5). The plots should contain a range of good environments. Then, the plots and surrounding areas are examined carefully using scuba on a regular basis, to look for factors likely to reduce setting densities. After the setting season, seed densities and survival in the plots and surrounding areas are compared. The plots can also be established to contain a single limiting factor, such as bay

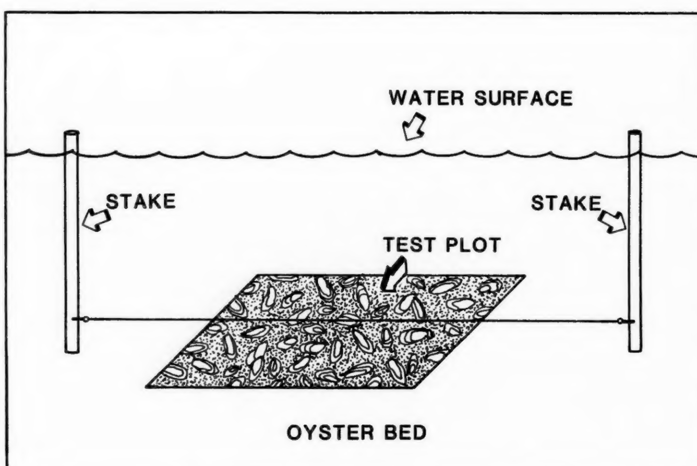

Figure 5.—Small plot set up on a bed to compare setting of oyster seed on test shells with that on shells nearby. A series of test plots may enable a specialist to identify factors that reduce productivity of the oyster bed.

anemones (MacKenzie, 1977d) or silt, to determine its significance.

Determining Causes and Extent of Seed Shellfish Mortality

A study of factors that cause seed shellfish mortality should start at the beginning of the setting season and, in the U.S. northeast, continue until perhaps mid-December when low temperatures slow down mortality rates substantially. Scuba swims over the beds can help to identify predators. While examining some oyster seed beds with scuba and then examining the spat on the deck of the boat in Delaware Bay, N.J., in 1986, I was able to determine that oyster drills and mud crabs killed most of the oyster spat. Other predators were scarce.

If potential predators are present in numbers on beds but their effects on shellfish are uncertain, two further steps can be taken. The first is to obtain a few thousand shellfish seed, perhaps 5-10 mm long, from a hatchery, spread them over small plots, perhaps 4 m^2 (4 $yards^2$) and observe them perhaps once a week. Take samples from these plots about once every 2-3 weeks, look for the predators in the samples and try to confirm their identity from characteristic markings on the shells of dead shellfish. The second step is to bring predators and seed into a laboratory and put them together in running water trays, to determine whether the predators feed on the shellfish. Fish stomachs can also be examined, if fish are suspected of being predators of clams or bay scallops.

A more thorough investigation of mortalities would involve shellfish collections from the beds for examination at a frequency of about once every 2 weeks during the warmer months. The shellfish and predators can be collected within a ring which encircles about a 0.3 m^2 (3 $feet^2$) at about ten typical sites per bed. The mortality causes are identified by examining the shells of killed shellfish and from knowledge of the presence of specific mortality factors. Continuous records are kept of the numbers of live and dead shellfish to determine the increases in percentages of dead shells of shellfish. Such counts are one of the most important aspects of the study, because they tell the importance of predators and they will be a main feature of reports to the public.

Feeding studies in running-water trays in a laboratory can provide some additional information. The numbers of individual shellfish consumed by each predator species per unit of time, such as per day or week, and the size ranges of seed that predators of certain sizes consume, can be determined. Similarly, the effects of reduced salinity and low and high temperature extremes on predators can be determined.

In some estuaries along the Atlantic coast, disease can be a major cause of mortality in oysters. Oysters can be examined for the presence of diseases if some die from otherwise unexplained causes. The possible presence of diseases in shellfish can be determined by sending samples to a biological laboratory which specializes in such studies.

Locations of Buried Oyster Shells

Fossil oyster shells under old oyster beds might be available as cultch for oyster larvae. These shells can be surveyed. Locations of buried shells can be determined from fishermen interviews and surveys from a boat or through the ice in winter. A hollow aluminum pole with which the surveyor can feel and hear the shells is an excellent tool for finding and measuring depths of the shells. A 19 mm (3/4-inch) diameter rigid, threaded pipe in 3 m (10-foot) lengths which can be coupled together is recommended. Follow-up checks to examine the surfaces of these deposits for depths of silt deposits and other features can be made using scuba.

Determination of Beds Closed by Pollution

This information should be available from the local health department. When data from surveys are available, a specialist can prepare charts which would show the topography of the estuary, the bottom types and the distributions of shellfish beds, salinity, and pollution. The charts of the shellfish beds would show areas having high setting densities and what limiting factors are important on each.

Shellfishery Operations and Statistical Profile

The information is gathered by direct observations and interviewing of fishermen, processors, and government personnel. A specialist needs to learn all the details of each operation of the shellfishery, emphasizing the design and use of each type of gear. In addition, he can gather data to form a statistical profile of the industry, because such profiles help to describe the fishery. Statistics are gathered on: 1) The number of boats and fishermen and 2) average shellfish catches per haul of gear and per boat per hour, day, and week, and the number of hours per day and days per week that fishermen gather shellfish. The gross and net earnings of a cross-section of perhaps ten fishermen and three or four processors and wholesalers, and a breakdown of overhead expenses are compiled if the data are available.

Identity of Key Groups Associated with Shellfishery Development

The groups of people to be involved with and affected by the program have to be identified. In addition, the power, incentives, and risks of each need to be determined and kept in mind when developing and thinking about implementing a program. These aspects can be determined by interviewing various people.

Conducting Pilot Studies

The state or local government would want to know what the payback would be for financial investments in its beds. Small-scale pilot projects would have to be conducted to provide this information.

It is essential that sufficient information be gathered in reconnaissance and intensive surveys to build a solid program. Consultations with other biologists and specialists should be made if any doubts exist about problems that are beyond a specialist's knowledge range. Too many times in the past, recommendations for shellfish development have been made from an inadequate information base, which is one of the reasons they were not implemented.

Educating the Public

For a technology or program to be implemented in a public shellfishery, the evidence for probable benefits has to be substantial and it has to be presented to the public properly. A shellfish production specialist has to inform the fishermen and local community about his findings through verbal, written, and, if possible, visual reports. Written reports should contain accurate data and be issued through an established, reliable source, and they should have sufficient quality to serve as permanent records. A sloppy report will irritate people and they will consider it to be unimportant, the product of a disinterested bureaucracy. In recent years, scuba divers have available video cameras which can record scenes of shellfish bottoms and gear. The tapes can be shown to audiences on TV monitors.

Educational Topics

Educational material can be presented as it is gathered on the following topics:

1) Setting potential of shellfish seed as compared with actual abundance on beds. The factors that limit setting densities are described.

2) The extent of shellfish mortality from small seed to the legal gathering length, probably on a monthly basis. Identity of the mortality causes and their relative importance are also described.

3) How use of a low-cost technology would increase shellfish abundance without risk to existing stocks or the environment.

4) The results from test plots that show larger densities of shellfish where a method was used to improve the shellfish's environment as compared with control plots.

5) Any pertinent information from the literature.

Distributing Reports

Educational material should be sent to all recipients simultaneously. Most shellfishing communities have a few unofficial leaders of points-of-view who may wish to remain as such. Thus, they may try to direct any new management proposals to their way of thinking. If they were to receive educational material from a specialist first, they may try to twist and downgrade their meanings in order that they can remain as the leaders of public opinion. When the other people finally receive the reports, their views towards a specialist's management direction will then be shaded. On the other hand, if everyone receives reports simultaneously, the unofficial leaders will have difficulty changing people's minds. The goals and direction of shellfishery management, which a specialist has developed in concert with the leading fishermen and members of the community and administrator, have to prevail.

In Long Island Sound, we sent a detailed report to each company after an examination of its beds. Examinations were made once every 2 weeks during the warmer months and once a month during the colder months. We were making a study over a 5-year period to identify and characterize the factors that limited oyster abundance. Most reports were analogous to a report card. They contained data which described the number of live and dead oysters on beds, the mortality causes and the presence of predators or silt on the beds, and the percentages of oysters that died within 2-week or monthly intervals. About 100 such reports were distributed. The concept of the percentage of shellfish dead was easily understood by the oyster growers. The possible methods for reducing mortalities were discussed verbally with the oystermen, who contributed ideas.

Once or twice a year, observations were summarized in a bulletin which was sent to all companies. One bulletin described the means of improving the conditions of oyster setting beds, and another dealt with the identification of and suggestions for reducing oyster mortalities. Afterward, oyster growers did improve the condition of their setting beds and they reduced mortalities from predation and smothering in silt; thus, quantities of their oysters rose substantially.

On Prince Edward Island, we issued five detailed reports to fishermen and two newspaper articles were released. In Mississippi, the time was not available for individual reports; nevertheless, two newspaper articles and a radio and television story were released which described the oyster resource rehabilitation program to the fishermen and public.

If a number of reports which contain information about high potentials for development are circulated and conversations have reinforced them, thinking patterns within the shellfishery concerning possible ways to increase shellfish abundance on the beds will likely be transformed from passive to active, with fishermen beginning to contribute more ideas.

A report describing an enhancement program which is to be implemented should be issued well in advance of any action, so people have time to think about it. If they are not given such consideration, they may obstruct the action even though they would have approved of it later. The fishermen and local people should not be railroaded into adopting an action.

Ideally, a specialist should try to present his findings in such a way that the community eventually pushes him towards developing and applying a program. He should not have to prod them into allowing the work to be done on the beds; rather, they prod him to do it. On Prince Edward Island, where the work involved transplanting oysters from poor to excellent bottoms which were otherwise barren of oysters, the fishermen were prodding me as an oyster production specialist to get on with it: "When are you going to get started," they needled. We did it by working closely for several months with the fishermen and local community and coming to the mutual conclusion that a large amount of benefit and no harm would result from such transplanting.

It is important that the educational process be continued after field projects are underway for two reasons. First, a time lapse might exist between the implementation of a program on the beds and when the first generation of seed attains market size. Money would continue to be spent on the program, but shellfish yields would not increase for a while. The only evident result would be much larger quantities of seed in the beds. Nevertheless, a specialist should

show seed samples to other local people and describe them verbally and in reports. The second reason is that after the program has been underway for a number of years and, it is hoped, fishermen's yields, incomes, and employment are substantially higher, the administrators, politicians, and local people may come to believe that shellfish abundance will remain high without the program. To maintain the public's positive attitude toward the program, a specialist would need to present the necessary evidence.

Shellfish production specialists would dispense the results of their work to other specialists and administrators by means of personal contacts, published papers in management journals, and viewings of video tapes.

Developing a Shellfishery Enhancement Program

The work which a shellfish production specialist does should be in the form of a program. The program should be outlined as it is developed, and eventually be written up as a formal report.

Objectives

A shellfishery enhancement program should provide economic and social benefits. Thus the objectives should be to increase or stabilize: 1) Economic security and productivity of the people working within the shellfishery, 2) employment opportunities and money supplies for the local community, and 3) shellfish supplies at reasonable prices for consumers.

Maintaining Productive Public Beds

The most good would emanate from a program in which shellfish production from the public beds was increased. An expansion of the public fishery would increase employment security and individual incomes, create more jobs and improve the economic life in the local community. In addition, in the case of oysters, more seed would be available for private beds. In a word, it would provide a wide sharing of the increased resource.

In developing a program, a specialist should ensure that the public fishery remains intact; he should try to develop technologies which will strengthen it. Such technologies may be more difficult to develop, but it does little good to develop any new ones unless they meet the needs of the public shellfishery. A specialist should not try to develop technologies for increasing shellfish production and then try to restructure the shellfishery to accommodate them.

Leasing Some Bottoms

An extensive leasing system currently exists in the eastern United States. Leases are mostly for oysters, but also for hard clams. Oysters are transplanted from public seed beds, which are sometimes in polluted water, to leased growing beds from which they are marketed. Hard clams are transplanted from public, polluted beds to leased growing beds from which they are marketed after a depuration period. In addition, hatcheries usually require leases to function.

Guidance from Local People

As mentioned earlier, success in developing a sound program can be achieved only by a group effort. Thus constructive advice from the fishermen, local people, other biologists, and fishery administrators is always sought and welcomed during the developmental process. Regular discussions are held with these people, especially the fishermen. Fishermen's minds are extremely alert to immediate problems, and thus they are excellent critics and can quickly point out the strengths and weaknesses of a technology and program. Discussions are also held with semi-interested local people to obtain perspectives on the merits of the proposed program. A specialist obtains answers to questions such as those listed below to determine the specific actions to be conducted.

For public beds:

1) What does the administrator want accomplished?
2) What does the local community want accomplished?
3) What do the fishermen, processors and wholesalers want and need?
4) What kind of projects do the fishermen want most to be implemented?
5) Is it feasible to make modifications for remedying deficiencies on each bed in question?
6) What is required to increase shellfish abundance in the beds?
7) What are the costs and benefits of a modification such as a reduction in predator numbers?
8) What resources (money, vessels, equipment and manpower) are available for making modifications?
9) What has to be constructed?
10) What stumbling blocks are present?
11) What laws and regulations that apply to the fishery have to be considered?
12) Do any risks to various associated people exist?
13) Will low-cost loans be available to the fishery if needed?
14) Will market promotion be needed?

For shellfish companies:

1) What do the shellfish companies, processors and wholesalers want and need?
2) What projects do the companies want most to be implemented? The remaining questions are the same as 5-14 for public beds.

Formulate a Program

The formulation of a management plan is done in steps:

1) Data on shellfish productivity, and positive and negative physical and biological features of the beds, are listed. Charts are examined that show bottom types and depths, distributions of shell deposits, predators, silt, pollution, and bottoms available for expanding beds.
2) The technologies needed to increase shellfish abundance are listed.
3) The rehabilitative measures which the fishermen desire and will accept on the beds are listed.
4) A program is designed which contains the best solutions with available resources for increasing shellfish abundance, and which states the objectives to accomplish within a certain time period.

Various combinations of available information and methods are fitted togeth-

er to try to form a workable, productive program. A specialist lays out a tentative plan, refits certain aspects, and adds new ideas and information to try to devise workable measures. It may not be possible to list a precise and definitive set of recommendations, and so a set of alternatives with an analysis of the consequences of each is then the best approach. A few recyclings of the plan will bring it into sharper focus, teach people more about it, and provide for much better critiques, while enhancing communication.

Keep Ideas and Gear Simple

The program has to be simple in concept so it can be easily understood by fishermen and local people. Moreover, the simpler the program structure (the fewer components it has), the better it will be conducted. An effective program might consist of only one type of action on the beds, accomplished by towing a simple type of gear over the bottom. Statements to the public about the program should be simple and clear. The simpler a statement is, the more powerful it can be.

Most advances in shellfisheries have stemmed from simple ideas. As examples, in the 1940's, the State of Maryland said that the oyster supply must be increased, and it could be done by spreading shells over barren bottoms. Huge quantities of shells were available in upper Chesapeake Bay. All the state had to do was to have the shells mined and spread over good setting beds; afterward, the seed oysters were transplanted to market beds. On Prince Edward Island, the oyster supply also had to be increased. In one area, quantities of oysters were available in a river channel; in another, they were available on an intertidal flat. In each case, all the Province had to do was to transplant them from those areas and later transplant quantities of fossil shells from other areas to suitable beds nearby.

I have been told that increasing shellfish abundance by means of environmental improvement on public beds cannot be achieved easily because it is too difficult to sell to the local people, i.e., it is too complicated to explain briefly. People do not want to get involved in complicated explanations and if they do not understand a program, they are not likely to support it, because they fear and resist what they do not understand. The public, which would be only semi-interested, usually wants to grasp an idea in only one or two simple mental images. Thus a specialist will have to develop simple statements to explain a program. A good rule is: Develop a program concept which takes no longer than 10 seconds or perhaps two sentences to explain. Some suggested examples are:

"We are going to wash the silt off the oyster seed beds; when we do it, seed abundance will increase substantially."

"We are going to control the predators because they consume at least 95 percent of the clams; when we do it, clam abundance will increase substantially."

"We are going to thin the eelgrass stands in the bay scallop beds; when we do it, scallop abundance will increase substantially."

The gear used to improve the beds should also be as simple as possible. Simple equipment is easier and cheaper to construct and is easier to operate; breakdowns absorb less time to repair.

Develop Technologies

New technologies may be needed to accomplish objectives such as: 1) Preparing oyster seed beds which have been in poor condition for receiving oyster sets, 2) controlling predators such as oyster drills and crustaceans on shellfish beds, and 3) modifying eelgrass stands on bay scallop beds. They would be used to prepare many acres of beds. In addition, technologies may be needed to help fishermen handle larger quantities of shellfish.

Only a small amount of engineering development work has been done in any aspect of shellfisheries, including equipment development for improving the condition of beds and the gathering and processing phases, by public or private agencies. Nearly all the gear now used has been developed by fishermen and blacksmiths who have had little time or money for experimentation with different designs.

The objective is to produce a technology that is appropriate or tailor-made to meet a specific need. By definition, if the technology is "appropriate," it will be adopted. Mahler (1980) discussed appropriate technology as follows: "The principle of appropriate technology... calls for sound materials and methods that are socially acceptable in a particular context, directed against relevant problems and effectively delivered, by affordable systems, where they are most needed. The generation of appropriate technology is not easy; often it calls for the highest scientific sophistication and perceptiveness...Appropriate technology is often simple technology, but it is not simple-minded."

A shellfish production specialist needs a correct attitude to develop the gear and implement the program. First, he should carefully define the objective which he is attempting to reach. Second, he should conceive a solution and then go right to work experimenting with prototypes. Third, he should test them and then fix the weak points to get them to work. He should not say: "It has never been done before, so let's not do it." The guiding principal is to "get the biggest bang for the buck," i.e., to produce a technology which yields the largest return possible in relation to its cost. A technology should not be more sophisticated and expensive than is necessary for the purpose.

A specialist has to take the entire responsibility for details about the design of a technology, or else be sure that such details can be mapped out by the blacksmith or workers in a shipyard. Otherwise, they might not construct anything unless the design is complete, including such details as the sizes of bolts and the bevel angle on the lip of a door hatch of a dredge. The reason is that they will not take the risk of being blamed if the technology does not work; they might not be paid for the work or they might lose future contracts.

When I was on Prince Edward Island, we gave a blacksmith the job of constructing two oyster dredges and a shipyard the job of constructing and rigging a catamaran which was built around the hulls of two lobster boats; they were to be used for transplanting oysters. Neith-

er had constructed them before and they did not know how to do it. The construction started off slowly and stopped more than once in each case. At first, it seemed as though the workers were merely slow and indolent. On closer inspection, we found, however, that they stopped at points where further construction details were not supplied.

We did not know the details of the dredge's design and had to ask an oyster grower in New York State to send photographs of a dredge. Upon seeing them, the blacksmith, with my nod, went ahead and quickly completed the dredges, which later worked very well. I remained with the workers in the shipyard for about a week until the catamaran was completed, taking responsibility for all estimates we had to make about the design; the workers completed all construction quickly when they were directed what to do.

Technologies which have the possibility of increasing shellfish abundances have been developed only rarely. It is likely when one is developed by the specialist and his associates that other people will be eager to test it. However, they are not likely to have the knowledge about how to use it correctly. Neither are they likely to have much patience when testing it, since they did not develop it. If their tests are unsuccessful, the technology may be discredited. Thus, a specialist should personally field test a technology which he believes will work. It is recommended that he should not mention the technology outside of his immediate working group, if he and the group cannot design and test it, for the same reason.

If a technology is being developed for fishermen, it is important to involve two or three fishermen in its development. This reduces the problems of technology transfer to other fishermen.

Judging Whether a Technology Will Be Successful

Assuming that an increase in shellfish abundance would meet the principal need of the fishery, a strategy is designed in which technologies are developed to control major limiting factors. The following aspects should be considered when designing such a technology or a program, to judge whether it will be successful.

1) Relative advantage. The fishermen and other associated key groups of people have to be shown that adoption will be beneficial: A substantial increase in employment and wages of the fishermen, at least as much as 50 percent. The fishermen and associated people in the program should all have incentive to have the technology developed.

2) Compatibility. The technology or programs must be compatible from three aspects: a) It must be practicable and mean no more than minor changes in any established fishing practices; b) it cannot harm other fisheries, and c) it must be acceptable socially (it cannot be a taboo symbol, which people might reject as unacceptable or improper to their value standards).

3) Simplicity. If people do not understand the goal and how it is to be reached, they will reject the idea.

4) Divisibility. It should be possible to test a technology on small plots which will not affect the principal beds.

5) Reversibility. The withdrawal from the use of a technology or program should be easy and without any lingering consequences if its use does not work. A permanent building or boat that cannot be used for any other purpose should not be constructed.

6) Relative expense. The new technology or program should absorb only a small amount of the local community's resources, including time, money and manpower.

7) Failure consequences. The use of a technology should not injure the shellfish or the beds in any substantive way or result in the loss of substantive time or money. The risks to the fishermen and the positions of associated key people in the program should be minimal.

Selecting Beds

Careful selection of beds to cultivate is important because returns will diminish rapidly if attempts are made to cultivate beds with major environmental deficiencies for the target shellfish; the costs of creating a favorable environment for shellfish may be too high on poor beds. Beds that contain many predators, whose numbers are expensive to reduce, should be avoided.

It is more efficient to make improvements on beds that already support commercial shellfishing, because: 1) They receive substantial shellfish sets almost annually, 2) most environmental factors for shellfish are nearly optimum, and 3) they usually have only one or two major limiting factors for shellfish. Management of a bed will involve searching out a fruitful middle ground between doing nothing and a complete overhaul of the bed's environment. It will require the specialist's best judgement to determine how much of a positive result an improvement will produce.

Using Hatchery Seed

The possibility of using hatchery-reared seed to increase shellfish supplies on the beds should be considered. The planting of hatchery seed would likely require less manipulation of the environments of beds, at least any bottom preparation to collect natural sets. Thus a community would be spared from doing this. After the seed is obtained, it would have to be spread on the beds and then be given some protection from predators. Before investing in hatchery seed, however, a community should estimate the number of these seed that will grow to market size and be gathered by the fishermen. Possibly, the quantity of natural seed already on the beds is many times larger than that of the hatchery seed to be added, and thus the gain in abundance of market size shellfish might not be worth the seed cost.

The existence of hatcheries makes it possible to increase the size of shellfish spawning stocks if these become too small to seed the beds. In addition, a specialist can obtain seed from hatcheries to make various kinds of tests on beds if natural seed is difficult to obtain.

Keep Risks Low

A specialist must try to lighten any risks which are present. Otherwise, the people who have put their economic future and their reputations and positions on the line for the program may become fearful that the risks are too large and withdraw support for the program, thus preventing implementation.

Set the Program on a Large Scale Whenever Possible

After pilot studies confirm its feasibility and establish its profitability, the program should be conducted on a relatively large scale to result in substantial increases in shellfish abundance and production. A specialist should design a program for public or private beds that will at least double or treble shellfish abundance if possible. If increases are smaller, local people might believe that they are from natural variations in abundance. Thus, many acres of beds should be improved.

Keep the Program Flexible

The design of a program should be flexible, because the community might change its thinking, conditions on beds might change, technologies might improve, or new information might become available about the beds. A specialist may have to steer around and between many fixed points to achieve success. If a particular course of action does not seem to be promising, the specialist must stop and ask himself what course will work.

Be Cautious About Introducing Technologies and Programs

A strong warning is made here against hasty, reckless implementations of new technologies on beds and new management programs. A specialist should keep in mind the words of the philosopher, Goethe, who wrote: "There is nothing more frightful in human affairs than ignorance in action." Nothing should ever be implemented that obviously threatens the earnings and security of fishermen; those should be guaranteed. A specialist should be guided by the physician's maxim: "First, do no harm."

The line between benefit and harm can be narrow. Even with the best of intentions and at the cost of infinite patience and care in planning, it is still possible for a boat, towing gear under the guidance of a specialist, to damage the shellfish and the beds. If the damage to the beds is extensive, shellfish abundance could be reduced for a considerable time. A safe way to introduce a method is to proceed slowly, making tests in small areas, then testing on increasingly larger areas, improving methods as tests proceed. Another conservative measure is to limit the number of trials in any one year; do not take on more than can be comfortably managed and observed.

In addition, serious consideration should be given to the character of a program, the number of methods implemented, and the amount of development desired in a shellfishery. Development can extend too far with harmful social cost. Overdevelopment might lead to the loss and spoiling of positive human values related to fishing.

A specialist should interview a large cross-section of fishermen and local people about the value of a technology or program, keeping an ear open to opposition to their use. The attitude of these people has to be used as the final judge of whether to implement the improvement. A specialist should back off and reexamine a proposal if many of the level-headed, responsible fishermen oppose it, although he can ignore opposition from the usual group of complainers. A good guideline is: If most fishermen are negative, the technology or program should not be implemented; on the other hand, if the fishermen are positive and urge a specialist to implement them, they should be implemented and it is likely they will be beneficial.

Consider Extension of Credit

A specialist may have to help some sector of the fishery obtain a loan, if the program has indeed produced an increase in shellfish abundance. For example, the private fishermen, buyers, and wholesalers may not have enough money for purchasing new equipment or the buyers and wholesalers enough money for sharp increases in shellfish supplies. This circumstance could markedly slow and inhibit development in the shellfishery. Money is available from banks but often only at exorbitant interest rates. The local government, as its part in the program to rehabilitate the shellfishery, might be able to offer low cost loans to fishermen and buyers or loan guarantees.

Consider Market Promotion

A specialist may have to become involved in market promotion if the program is to succeed, because the market may not purchase a sudden increase in the shellfish supply. If market demand for the shellfish is weak, increases in production will be minimal at first, even though supplies are increased. Besides, most markets will not absorb an ever-increasing supply of a food crop, including shellfish, without resistance in the form of falling prices. If prices fall substantially, the fishery may reach a point where it is handling relatively large quantities of shellfish at low prices, a condition which translates into increased work and use of equipment while not yielding higher incomes. Thus the enhanced production must fit into the supply and demand characteristics of the region, and if supply exceeds demand, the consumers, not the fishermen, benefit.

Promotion of shellfish in distant markets is far beyond the scope of the public fishermen and small companies to conduct, although local seafood festivals can contribute to market development.

Market promotion can be as simple as the alerting of wholesalers that supplies will become larger in the near future and sending shellfish samples to wholesalers to let them see the quality of the product. Promotion can also involve advertising by a public agency. In the late 1960's and early 1970's, the Marketing Services Division, National Marine Fisheries Service, Gloucester, Mass., promoted oysters at the request of the Oyster Institute of North America, to help relieve an over-supply caused by the irruption in oyster abundance in Long Island Sound. The promotion involved placement of oyster recipes in newspapers and national magazines and preparing a recipe for a cooking program on national public television. No analysis was made concerning the effectiveness of the promotion, but the Long Island Sound oyster companies related that the market demand for oysters did improve.

Write a Planning Document

It is desirable that the details of every

technology to be used and all phases of a program be described in a report. Such a report is essential if in an unfortunate circumstance the specialist does not happen to be present to supervise and handle all phases of the implementation of a program. The beds are not likely to be rehabilitated if the details of the program are incompletely known, because the next person to be in charge, perhaps a person who had been an associate specialist, would not like to guess about conducting any phases of a new program. He would fear that he will make mistakes and be held accountable for them. In a circumstance in which every phase is clearly described, he could blame the program or its authors if the result is negative. Another reason for a detailed report relates to the fishery administrators and politicians. If they do not understand all aspects of a program and cannot be convinced that they will be successful, they will likely postpone authorizing its implementation. They, too, may fear that it is unsound and will weaken the shellfishery and thus threaten their positions.

A well conceived program will likely change the mood of the fishermen from conservative and negative to optimistic and positive. The effect will stimulate further actions to control secondary predators and to develop other areas which currently limit the shellfishery. On the other hand, a poorly conceived program will contribute to general malaise and disillusionment within the fishery and local community about the capability of government bodies to act constructively.

Putting a Technology Into Use or Implementing a Program

An anonymous author once wrote: "The great end of knowledge is virtuous action." Transferring knowledge and ideas into human affairs, however, is usually extremely difficult. In recorded history, only an infinitesimally small proportion of ideas proposed for development in any realm of human affairs has ever been implemented; moreover, a high percentage of implemented ideas has not endured. Heretofore, no list of rules or suggestions for implementing shellfish technologies and programs has existed, and thus a discussion of implementation and such a list will be presented here.

Some Guidance From the Agricultural Literature

Since its inception, the formal field of scientific agriculture has had a great deal of experience in trying to transfer its findings to commercial farming practice. Nevertheless, only in the past 30 years or so has the field developed some useful literature on the subject. Nearly all writers emphasize that the span from proposal to implementation is usually long and precarious. They also emphasize that the rate at which an innovation is adopted depends on its profitability. The following comments and rules about implementing from the agricultural literature are instructive.

Gable and Springer (1976): "The process of innovation is much more complicated in agriculture than industry, where a vast technology exists and is often transferable without modification. In agriculture what is known is not always easily transferred or adapted. Farming is only partly subject to human control; climate, soil, water, wind and so on are difficult to manipulate. To the extent that the human factor is influential, there are millions of individuals who have to be informed and motivated to change—and the advantages of new processes have to be clearly demonstrated. Where risks are high, the persons who are wholly dependent on their own production for survival may be the least willing to innovate. The task of government—to achieve agricultural development in the least-developed countries—is monumental".

Chambers and Wickremanayake (1977): "Technology presented to farmers should be worth adopting, as all too often it is not. Where innovations are highly beneficial, they will be adopted rapidly, extension or no; and conversely, no amount of excellent communication can spread a poor innovation."

Chambers and Maxwell (1981): "Implementation. . . is the crux. Good ideas which are not implementable are bad ideas, at least for the time being. The best way forward may be to develop a repertoire of interventions which are simple, manageable, replicatable and effective, and which involve rural people as partners. Analysis is the easier part; the greater challenge is action. Ways forward may be sought through combinations of analysis, action programs, evaluation and then training and replication. Such measures might. . . increase agricultural production and benefit those who are poorer and weaker".

Paddock and Paddock (1964): "Farmers, like everyone else, cannot afford to try out the new until convinced it will pay a higher profit than the present. Telling them is not enough. They must see the results demonstrated before their eyes in their own valley".

Wortman and Cummings (1978): Regarding the success of the wheat program in Mexico in which new varieties were adopted rapidly by farmers, they say, "Research and extension were combined. As the researchers solved the problems limiting production, they demonstrated repeatedly—at field days, on private farms, to national leaders and to farm groups—how higher yields could be obtained. Instead of separating research and extension there was one program that began on the research station and ended with use of the varieties and practices by the farmers."

Some Guidance From the Industrial Literature

Reisman and deKluyver (1975) list some useful points about program development in an industrial setting which also apply to programs for enhancing shellfisheries. Most of these points about implementing have been mentioned already, but since effective implementation has been so rare it is worth restating them in this slightly different context.

1) The researcher should secure active participation of management (in shellfisheries, the fishery administrator and politician) and the ultimate user (in shellfisheries, the fishermen, processors, and marketers) throughout the study, particularly in the initial phases when the program is planned, the problems defined and the methodology selected. Moreover, the users should become involved enough in the study to accept it as at least partially theirs. A study done

in isolation of management and the users will meet with a great amount of resistance in the implementation phase. Unless the users are intimately familiar with the study, a) the researcher may have the wrong perception of the users' needs and solve, albeit correctly, the wrong problem and b) the users will feel uneasy about the researcher's presence. Users are the key to success; they must be involved from the outset—the deeper the better.

2) Select projects which have a high probability of success. That is, projects that take a relatively short time to complete, are relatively simple in the technical sense, and have high potential. The objective is to impress people with results that are immediate and highly visible. There should also be long-term objectives that involve basic studies and projects that have higher risks involved.

3) Before the decision to implement is made, potential results should be carefully examined. This confirmation process can take many forms. Experience shows that simulation (results on test plots of shellfish) can be a powerful tool in this process. With this technique, it is possible to show management, using the same data set, how the present system (the uncultivated beds) operates, how management thought the present system was operating, and how the new system (new shellfish management program) might operate if the new decision rules are used. It implicitly demonstrates the results of the study and generally makes a strong impression on management. This kind of reporting is easily understood by and communicated to management and thus favors the chances for implementation.

4) Continuous reporting of data and continuous planning for implementation during all phases of the study are emphasized as other important determinants of success. A postaudit after the implementation and elimination of initial bugs in the new system is advisable.

Some Additional Rules

A technology should be completely developed and proven effective before being shown or demonstrated to fishermen. The purpose is to maintain the shellfish production specialist's credibility: He demonstrates only finished technologies that work.

The purposes of increasing the mechanization of gathering shellfish by fishermen are to increase the productivity or output of fishermen and vessels or reduce the fishermen's work load. Development of a new technology for gathering shellfish is difficult and exacting, because it has to: 1) Fit easily into the existing cultivation system, 2) have reasonable cost, 3) provide for a short-term (1-4 weeks or, at most, a season) recovery of the money which it costs the fishermen, and 4) provide a gain that is guaranteed, save for unplanned events such as poor weather. A fishermen or company will use a new technology only if it meets a need or otherwise represents a better alternative to one which they already use.

Increased mechanization of harvesting gear in the public shellfishery has to be planned carefully. If unwisely used, it could reduce employment. For example, if fishermen were allowed to use a more efficient type of equipment, such as larger dredge for oysters, each fisherman would take more oysters per day, assuming that no daily limit on the catch exisited. The result might be a larger than usual supply in the market, causing a drop in price, and a more rapid than usual depletion of oysters from the beds, causing some unemployment. Increased mechanization for increasing gathering rates should be considered only when a program that increases shellfish supplies on beds and promotion of oyster sales is underway.

A problem with implementing an improved technology in a private fishery is: Which company will construct it first? In practice, a progressive company will usually try it and then the others will copy it if it works. The progressive company is disadvantaged because it has to work out any procedures for using it. Moreover, the remaining companies will probably improve the design of the technology, leaving the progressive company with the least efficient, most expensive model. The progressive company can be "reimbursed" by receiving more assistance from a specialist than the others. Progressive companies will usually try out new methods, at least on a small, inexpensive scale, to encourage continued developmental activity by public agencies.

A shellfish production specialist has the responsibility for personally implementing and initially overseeing the conduct of the program. A specialist should not give the responsibility for implementing a program on a commercial scale to someone else and then leave the community. If he does, no further actions are likely to take place and thus the assignment will not be successful. If the person left in charge tries to implement the program and cannot do it properly, the assignment of a specialist will still be unsuccessful, even though the specialist may say: "The program worked well in the pilot tests; thus the fault lies not with the program, but with poor implementation." The program could probably be implemented by the associate specialist if he has a detailed report to use as a guide. A separate problem with the specialist's leaving is that other people may have different plans. If so, when he leaves, these people will encourage use of their own plan, while discouraging the use of his.

A specialist can follow the steps listed below to initiate implementation:

1) Design the introduction. Look for channels, allies; consider timing and climate (Is this a good time?).

2) Ask for a final review and approval by the fishermen and local people. The tone of presentation should be supportive and adaptive, rather than revolutionary with recommendations to displace traditional elements.

A specialist has to have some control over resources and people during the implementation phase. Initially, he should define the jobs that are necessary to implement the strategy and then find people with the necessary skills and desire to carry it out. He should supervise the construction of any technologies and have responsibility for using them on the beds, and he has supervisory responsibility over the boat captains and crews.

An enhancement program will work only if it is well conducted, no matter how well it was designed. Every operation must be executed well to achieve

the desired result. Operations should be designed with some built-in safety margins.

When vessel operations begin with a technology being towed, the beds involved should be inspected regularly, two or three times a week at first with scuba, if possible, to determine whether adjustments should be made. Sometimes, only a slight adjustment in procedure by the boat crew can substantially increase the quantity or quality of shellfish produced. If any major mistakes are made, the fishermen may discover them later, and, most likely, they will criticize the program. If the criticism is severe, the administrator or politicians might have to discontinue the program.

If a specialist is willing to direct the implementation and oversee early operations, it proves that he believes in the program. Thus the fishermen and local people will have much more confidence than if the program is not supervised in the beginning or if he leaves the scene and asks someone else to oversee it.

Coordinating and Guiding a Program

Coordinating Production Routes

The potential actions of each component directly and indirectly related to shellfish production ought to be coordinated by a shellfish production specialist to bring about an actual increase and stabilization in production and supplies to the market. If more shellfish become available on the beds, the fishermen will gather more for sale and more will be available for the remaining components to purchase. Each has to be prepared to handle the shellfish and each will anticipate a larger profit from handling them. Consumers will have to be convinced that the shellfish is a better choice than the other food they usually buy. Coordination might involve helping to attract new buyers to the shellfishing business, arranging low cost loans for buyers and wholesalers, modifying truck routes, and arranging for market promotion.

Annual Consultations

After the establishment of a program to increase shellfish abundance in a locality, it is necessary for a specialist to consult, at least several days a year, with operating personnel on the beds and local fishermen, administrators, and politicians. Such consultations would include examinations of each bed and discussions about: 1) What actions to take to maintain high shellfish abundance, 2) how to keep the program on track, and 3) how to improve efficiency of operations. A program may gradually fail to function if not stimulated by such consulting. The presence of a specialist is also needed to maintain a program in a private shellfishery.

Handling Opponents of a Program

It is likely that fishermen and the local people will support a sound program which produces substantial increases in shellfish abundance and earnings without damaging the beds. Nevertheless, a tiny minority of fishermen may oppose the program. These will usually be fishermen who have low status and who habitually oppose new ideas. They may consistently look for weaknesses in the program and then spread negative rumors to sabotage it. Their activities have some benefit because they keep the specialist alert about all factors regarding the program. The negative rumors can be quelled through conversations, issuing of reports and showing samples of shellfish from beds. The program is also maintained on course by:

1) Anticipating questions or arguments in advance and having well-prepared answers for them. The most common question will be: what is the program going to do for me?

2) Avoiding statements that are not factual; thorough knowledge of all aspects is required to do this.

3) Being aware of negative rumors; if they do arise, nipping them in the bud.

4) Having a consistently positive attitude; confidence that operations on beds will be successful is required.

5) Not making mistakes when conducting field operations; thorough knowledge and constant supervision at the beginning are required.

Some Remarks About an Assignment

Handling Unanticipated Crises

Possibly, the shellfish beds of a community will be threatened by some kind of external development. The development might include: 1) Channel dredging through the beds, 2) filling of beds or a nearby marsh with sediment, 3) construction of a marina or housing on the shore, 4) mining of sand and gravel, 5) diversions of fresh water, or 6) the spreading of pollution from a sewage plant, industry, or nonpoint source. Some of these proposed environmental developments may have little to do with shellfish production. The community may consider that the shellfish production specialist is their biological and environmental expert and thus may expect him to predict the effects which the developments will have on aquatic habitats and shellfish. Thus they may ask him to represent the community's interests in public hearings on these matters. Another type of crisis is of a personal nature. A fisherman might have some misfortune such as an illness in his family and turn to the specialist for spiritual comfort. A specialist has the responsibility to handle such crises to the best of his ability.

Initiating an Assignment

Most likely, an administrator of a town, county, or state government, or manager of a shellfish company, would seek out a shellfish production specialist to develop a shellfishery enhancement program for itself. However, such authorities may not be aware that any potential exists for increasing the productivity of its shellfishery. A way in which a specialist can initiate an assignment is to ask these authorities if he could make studies of the condition of its beds for settlement of larval shellfish and mortalities of seed. After a few months, the specialist would then present his data to the authorities and describe to them how the control of factors limiting shellfish abundance would enhance their shellfishery. He would then try to convince them to support him in an enhancement program.

When Should an Assignment Begin?

In an assignment in which the objective is to increase the shellfish supply, the most important activities on the beds will be to identify the factors that limit it. Thus, an assignment should start near the beginning of the setting period. My assignments in Prince Edward Island and Mississippi, which began in early August and about the first of July, respectively, were during oyster setting seasons. I was able to evaluate the conditions of the major setting beds.

How Long Should an Assignment Last?

This depends partly on the experience of the specialist. I believe that a year is the minimum time for a specialist to evaluate conditions, develop appropriate technologies, set up a sound program, convince people that it is sound, and train an associate specialist and the boat captains and crews to run a program so it can continue if he should leave. My assignment in Mississippi lasted only 5 weeks, the month of July 1975 and 1 week in November 1975. As mentioned above, I was able to determine that the oyster reefs were in relatively poor condition for receiving an oyster set, to test a technology for removing mud from one of the reefs, and to set up a vessel owned by the state for transplanting oysters. In addition, I was able to write a report of recommendations to improve the oyster fishery. However, the time was not available to develop a better program or more technologies, to train personnel on vessels to operate the technologies, or to allow time for fishery administrators in the Mississippi Conservation Commission to become familiar enough with the program to see that it continued. The program endured for only a few weeks after I left, with little result.

Who Deserves Credit for Success?

A successful shellfish enhancement program will have many contributors. Each person involved will probably feel that he or she contributed more than he actually did; it is human nature. A specialist should use the pronoun "we" rather than "I" when discussing credit for a successful program.

Some Final Thoughts

In the past, "field work" in shellfisheries management usually has been given to the least trained personnel on the staff of a fisheries agency. As biologists gained in experience, they were given increasingly less field duty and increasingly more administrative duties and were replaced in the field by people with less experience than themselves. In many instances, the experienced biologists became full-time administrators. Developmental work involving the identification and control of limiting factors of shellfish in commercial beds and interactions with fishermen, local people, and administrators and politicians, however, requires the first-hand involvement of highly capable and experienced people to be effective. Thus, perhaps we should follow the policy of the public health field in which the most highly trained and capable people, i.e., the medical doctors, are the people who deal with patients and have the most experienced, highly paid people doing the field work.

The tone of this paper may sound too optimistic to some readers. It is not easy to manipulate some underwater shellfish environments. For instance, control of oyster drills and crabs has not, as yet, been achieved in most places, though it has been attempted sporadically for many years.

This guide for the enhancement of shellfisheries in estuaries and bays might also be applied to shellfisheries on the continental shelf off the eastern United States. Commercial fisheries for the surf clam, *Spisula solidissima*; ocean quahog, *Arctica islandica*; sea scallop, *Placopecten magellanicus*; and calico scallop, *Argopecten gibbus*, exist on the continental shelf. The surf clam and probably the other three species have predators which take nearly all of their juveniles (MacKenzie et. al., 1985). It may be possible to adapt this enhancement guide to increase abundances of these shellfish.

Conclusion

The shellfish resources on public beds within estuaries and bays of eastern United States are the common property of local citizens. Abundances and yields of shellfish can likely be increased substantially in many localities. The increases will be for the benefit of us all and will fulfill the aspirations which local people have had for prosperous shellfisheries. The prevailing uncertainty of fishermen about the future will be replaced with a reasonable degree of stability, predictability, and prosperity. Fishermen will gain larger earnings and perhaps longer working lives and can remain in their communities working in a preferred occupation. Improvement in the economy of the entire shellfishery and local communities will follow and a more controlled, larger supply of moderately priced shellfish will be available for our citizens. A shellfish production specialist and administrators will likely achieve such a result if they enjoy their work, have the fishermen's best interests at heart, treat people as individuals, and are truthful and honest.

Part II: Reference Material

Part II of this guide provides shellfish production specialists with background information about the shellfishing industries in eastern United States. It is composed of four sections. Section I describes the distributions and yields of oysters, hard clams, soft clams, and bay scallops. Section II is a statistical summary of the shellfishing industries. Section III describes the life cycle of shellfish, factors governing their abundance, natural fluctuations in abundance, and the condition of beds. Section IV describes characteristics of shellfisheries and shellfishermen of eastern United States; it is rather extensive because such a description has not been made before.

Section I. Shellfish Distributions and Yields

The broad, mostly level-bottom estuaries and bays of eastern United States contain many shellfish beds whose areas range in size from a small fraction of a hectare, or less than an acre, to at least a hundred hectares (250 acres). Typical water depths over the beds are 1-5 m (3-16 feet), but the beds may extend to

the intertidal zone (oysters and soft clams) and to at least 15 m (50 feet) (oysters and hard clams). Within the beds, shellfish have a random distribution and are commonly in large patches or ridges. Usually, the oyster and soft clam occupy the brackish areas, whereas the hard clam and bay scallop occupy zones where salinities exceed 15‰.

Shellfish beds have a broad spectrum of biota. Besides the commercial shellfish, an array of gastropods, crustaceans, polychaetes, algae, and many others also inhabit the beds. The total biomass on oyster beds is much larger than it is on nearby bottoms (Arve, 1960; MacKenzie, 1981).

Distributions of Shellfish

The American oyster ranges from Maine to Texas (Fig. 6, 7). The hard clam ranges from Maine to Florida (Fig. 8). The soft clam ranges from Maine to North Carolina (Fig. 9). The bay scallop ranges from Massachusetts to Florida (Fig. 10).

A substantial portion of market oysters have been harvested in private beds, but most had set and grown for a while in public seed beds and were later transplanted to private beds for additional growth or sometimes for the cleansing of bacteria before harvesting. In 1979 oyster production along the Atlantic Coast was 4.3 million bushels and their landed value was $36.4 million. Most of the seed oysters came from public beds, while Maryland and Virginia were the two states leading in production (Fig. 6). Oyster production from the Gulf Coast was about 2.6 million bushels and their landed value was $17.5 million. Most of the seed came from public beds. The two leading production states were Louisiana and Florida (Fig. 7).

Hard clam production along the Atlantic Coast was about 1.1 million bushels and their landed value was $33.3 million. Most of the hard clams were produced from public beds. The leading production state was New York (Fig. 8).

Soft clam production from Maine to Virginia was 630,000 bushels and their landed value was $13.3 million. All soft clams were produced from public beds. The states leading in production were Maine and Maryland (Fig. 9).

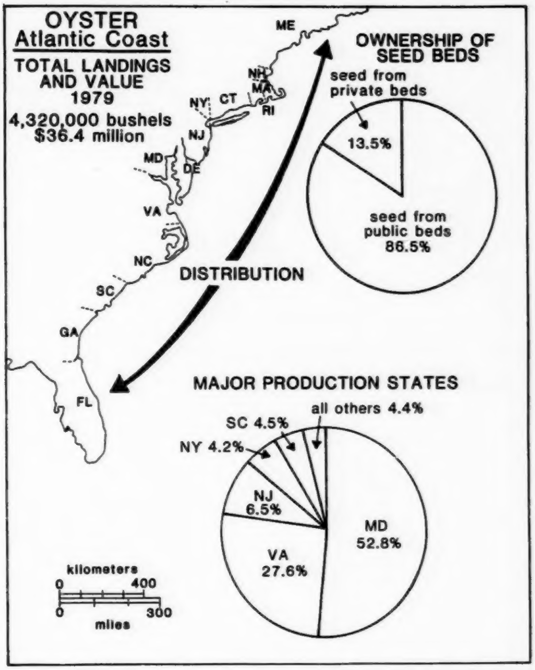

Figure 6.—Atlantic coast oyster: Landings, value, distribution, ownership of seed beds, and major production states in 1979. (Source: Anonymous, 1946-79.)

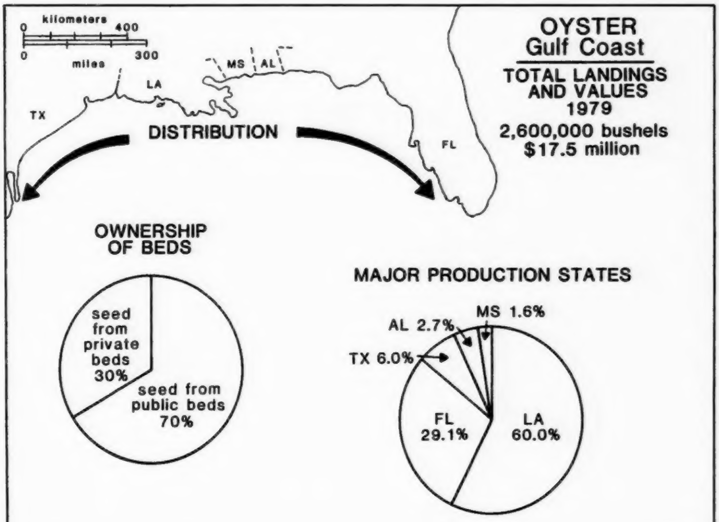

Figure 7.—Gulf coast oyster: Landings, value, distribution, ownership of seed beds, and major production states in 1979. (Source: Anonymous, 1946-79.)

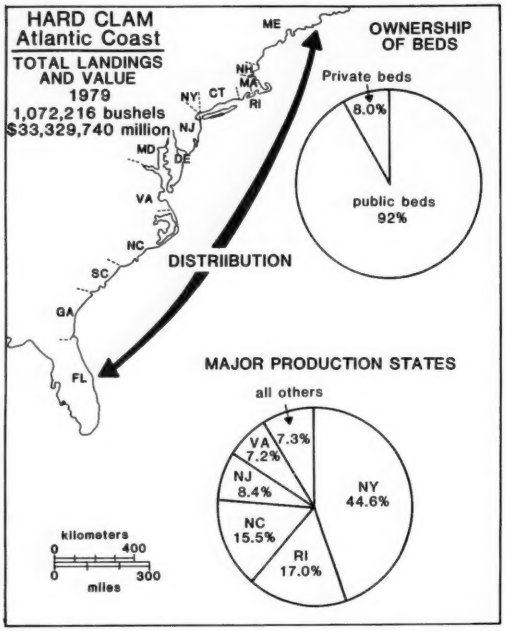

Figure 8.—Hard clam: Landings, value, distribution, ownership of beds, and major production states in 1979. (Source: Anonymous, 1946-79.)

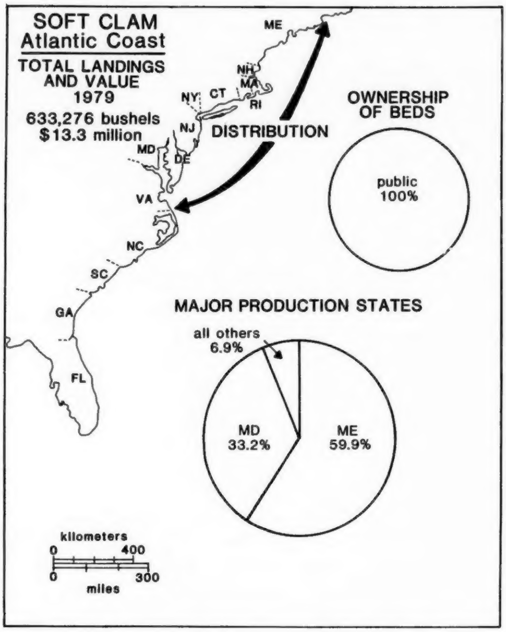

Figure 9.—Soft clam: Landings, value, distribution, ownership of beds, and major production states in 1979. (Source: Anonymous, 1946-79.)

Bay scallop production from Massachusetts to North Carolina was 190,000 bushels and their landed value was $3.9 million. All bay scallops were produced from public beds. The states leading in production were New York and Massachusetts (Fig. 10).

Comparative Yields of Shellfish and Agricultural Crops

Much more can be grown underwater per unit of area than on land. The values presented in Table 6 for shellfish are for beds that are productive; they are conservative and typical, but do not include beds where shellfish are relatively scarce and support only marginal fishing. In nearly every case, the value of crops produced per acre is much higher for shellfish than for grains. The relative value of shellfish from beds explains why fishermen tenaciously protect the beds.

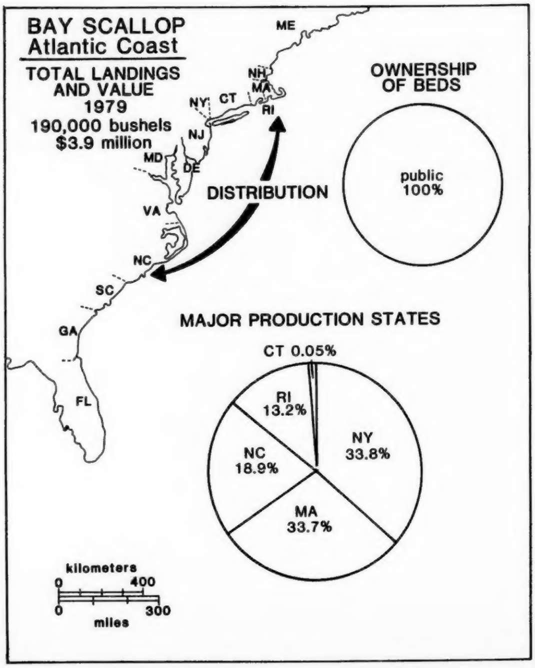

Figure 10.—Bay scallop: Landings, value, distribution, ownership of beds, and major production states in 1979. (Source: Anonymous, 1946-79.)

Section II. Statistical Summary of the Shellfishing Industries

The statistical base for shellfisheries is rather weak. Statistics on monthly and annual landings and value of shellfish from most states and a few state counties are compiled by the National Marine Fisheries Service, NOAA. They are available to the public. Companies are not required to report their landings to a public agency if less than three companies sell shellfish from any jurisdiction even if it is as large as a state. The reason is to ensure that companies can keep their volume of sales and related business matters private. In some instances, local towns publish shellfish statistics in their annual reports and these are available in local libraries.

No published statistics are available on: 1) Landings from Connecticut and Delaware; 2) most smaller units than states, such as towns and state counties and also bays and estuaries (Delaware Bay, N.J., is one exception), and 3) working and earnings profiles of fishermen and workers in processing plants. The lack of statistics on small units means that the large fluctuations in their shellfish production among years is not apparent; when all units of a state are totalled together, their sum may show little variation among years. Thus it is not apparent from the statistics that productive employment of fishermen and workers in processing plants in local areas often varies considerably among years.

This section includes: 1) A listing of statistics for 20 years of landings and prices of shellfish from Maine to eastern Florida and from western Florida to Texas, 1960-79, 2) annual shellfish production from small units, 3) seasonal landings, and 4) the determinants of landed prices of shellfish.

Table 6.—Comparison of typical annual yields and values of crops per acre, 1976 yield and prices.

Crop	Bu. per acre	Pounds shucked meats	Value ($) Per lb.[1]	Value ($) Per acre	Source
Shellfish					
Oyster					
Long Isl. Sd.	500[2]	3,750	2.51	9,398	
Maryland	100[3]	500	1.07	533	8
Florida	400[3]	1,600	0.64	256	9
Hard clam	50[3,4]	600	2.00	1,200	
Soft clam	50[3,4]	675	1.13[5]	760	
Bay scallop	50[3,4]	300	1.97	590[6]	10
Grain[7]					
Corn	88			189	11
Wheat	30			82	11
Soybeans	26			178	11

[1]Dollar values from Current Fishery Statistics, National Marine Fisheries Service.
[2]Private beds; market beds only.
[3]Public beds.
[4]Estimated.
[5]Average of Maine and Maryland.
[6]Average of Massachusetts and New York.
[7]Average U.S. yields and value.
[8]Galtsoff, P. S. 1956. Ecological changes affecting the productivity of oyster grounds. Trans. 21st N. Am. Wildl. Conf., Wash., D.C., p. 408-419.
[9]Whitfield, W. K., Jr. 1973. Construction and rehabilitation of commercial oyster reefs in Florida from 1949 through 1971 with emphasis on economic impact in Franklin County, Fla. Dep. Nat. Resour., Mar. Res. Lab., St. Petersburg. Spec. Sci. Rep. 38, 42 p.
[10]Marshall, N. 1960. Studies of the Niantic River, Connecticut, with special reference to the bay scallop, *Aequipecten irradians*. Limnol. Oceanogr. 5(1):86-105.
[11]Statistical Abstract of the United States: 1980 (101st ed.). U.S. Bur. Census, Wash., D.C. 1980.

Trends in Landings and Prices, 1960-79

Oyster

Between 1960 and 1962, annual landings of oysters from Maine to eastern Florida fell sharply to 6 million bushels in 1962 from about 7.5 million in 1960; except for a drop to 4.5 million bushels in 1977, landings remained about level from 1962-79 (Fig. 11). Between 1960 and 1979, real (inflation-adjusted) prices for oysters declined about 20 percent to about $2.50/bushel from $3.00-3.50/bushel in 1960-61. The inflated price was $5.25/bushel in 1979.

Between 1960 and 1979, annual landings of the oyster from western Florida to Texas fluctuated from 3.3 to 6.1 million bushels; the trend was about level (Fig. 11). Between 1960 and 1979, real prices for oysters about doubled to $2.25/bushel from about $1.10/bushel in 1960. The inflated price was $4.60/bushel in 1979. The price of these oysters, which had been only about 33 percent as high as Atlantic Coast oysters in 1960, rose to within 90 percent as high in 1979.

Hard Clam

Between 1960 and 1979, annual landings of hard clams (all size categories combined) varied somewhat, but showed a downward trend after 1976; landings ranged from about 1.1 to nearly 1.5 million bushels/year (Fig. 12). In 1979 hard clam landings were about 1.1 million bushels. From 1960 to 1979, real prices for little necks nearly doubled, rising to $25/bushel in 1979 from about $13-14/bushel in 1960; the inflated price was $60/bushel in 1979. Real prices for cherrystones increased by about 20 percent, rising to $9/bushel in 1979 from about $7.50/bushel in 1960. Real prices for chowders increased by about 22 percent, rising to $5.50/bushel in 1960; the inflated price was $12.50/bushel in 1979 (Fig. 12).

Soft Clam

Production of soft clams rose to 1 million bushels in 1969 from 670,000 bushels in 1960; afterwards, annual landings fell to between 600,000 and 700,000 bushels from 1972 to 1979 (Fig. 13). Prices of the soft clam are considered for only the two leading producers, Maine and Maryland (Fig. 13). The prices of Maine clams ranged from about $6.00 to $7.00/bushel through the 1960's. Real prices were higher during most of the 1970's and were $9.00/bushel in 1979; the inflated price was $21.50 in 1979. The prices of Maryland clams ranged from about $2.50 to $4.75/bushel through the 1960's. Real prices fluctuated between $4.25 and $10.35/bushel in the 1970's; the inflated price was $22.50 in 1979.

Bay Scallop

Between 1960 and 1976, annual landings of bay scallops ranged between about 185,000 and 525,000 bushels, but the trend was about level; in 1977-79 production was lower and ranged between 110,000 and 180,000 bushels/year (Fig. 14). Prices of the bay scallop were considered for the two leading producers, New York and North Carolina (Fig. 14). Prices are given as the values of shucked meats because that is the form in which scallops are usually sold. Real prices of New York scallops were variable between 1960 and 1979, but the trend was upward. The price rose to $1.50/pound in 1979 from $0.80/pound in 1960. The inflated price was $3.60/pound in 1979. Real prices of North Carolina scallops were about level from 1960 to 1976 at $0.38-0.90/pound; afterwards, they rose

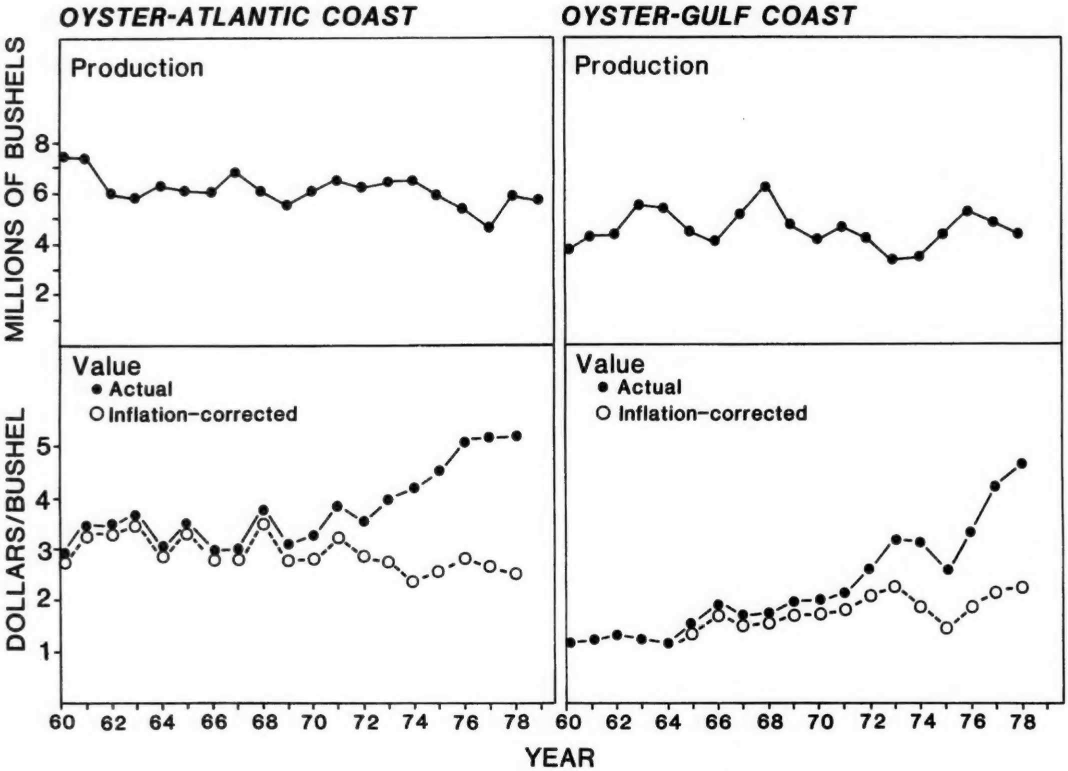

Figure 11.—Landings and prices of oyster, 1960-79. (Source: Anonymous, 1946-79.)

to \$1.11/pound in 1979. The inflated price was \$2.66/pound in 1979.

The rises in prices of littleneck hard clams, soft clams, and bay scallops show that their demand was rising in the market. If market conditions remain the same, production of these shellfish could be increased without a drop in prices; perhaps only minimal promotion would be needed to maintain prices. Probably, an increase in the production of oysters, however, would require market promotion to prevent further price declines.

Trends in Landings from Small Units

Annual landings statistics for hard clams, soft clams, and bay scallops from four counties (8 years) and a town (20 years) in Massachusetts show the considerable variation in landings among years that exists in local areas (Fig. 15, 16). The landings totals reflect the variations among years in employment and earnings that occur in shellfisheries from small units. They do not precisely show the availability of shellfish in beds, because landings are a product of availability and effort. Shellfishing effort varies somewhat with employment opportunities ashore.

Seasonal Landings

Landings of the four shellfish species are seasonal. The oyster and bay scallop are landed mostly in the autumn and early winter; the hard clam and soft clam mostly in the spring and summer (Fig. 17). The seasonal patterns generally relate to shellfish biology, market preferences, and the presence of ice in the bays and estuaries in winter. The oyster has thin meats in summer and when shucked then yield poorly. Oyster meats are fattest in late autumn and winter; thus, yields per bushel are highest and it pays fishermen to sell them then. Bay scallops grow rapidly during summer and autumn, attaining their full size in the late autumn; it pays fishermen to sell them when they have attained their full size. The hard clam and soft clam also grow most rapidly during the summer, but consumers prefer them when they are about 5-6 cm (2.0-2.5 inches) long rather than when they are larger. Moreover, they are popular in restaurants and snack bars in summer. Finally, many coves and bays where the two types of clams grow become cov-

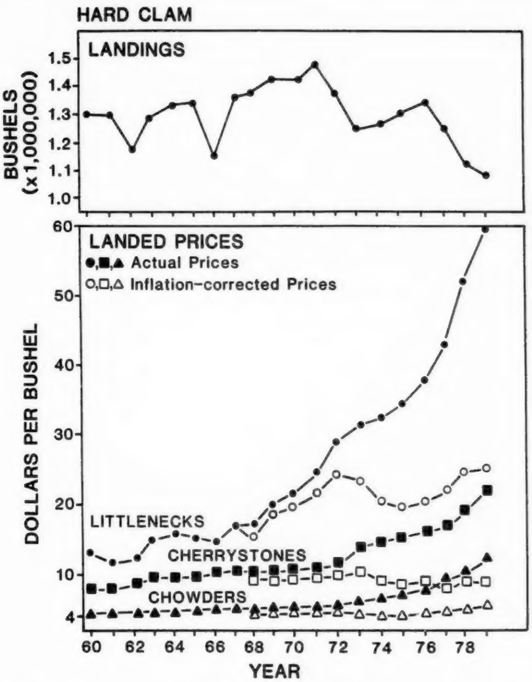

Figure 12.—Landings and prices of hard clams, 1960-79. (Source: Anonymous, 1946-79.)

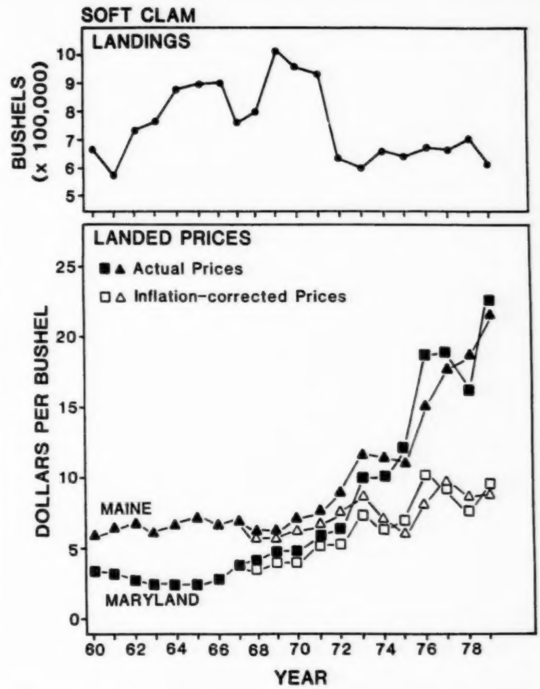

Figure 13.—Landings and prices of soft clams, 1960-79. (Source: Anonymous, 1946-79.)

ered with ice during the winter, making fishing for them on a commercial scale difficult.

Determinants of Landed Prices

The landed prices of shellfish are governed by two opposing forces: 1) The requirement of fishermen to earn an adequate daily wage and desire for higher prices and 2) the requirement of retail stores to maintain prices reasonably close to those of finfish and meats. The prices which fishermen receive allow them to work about an 8-hour day while earning about the same as if they were working ashore. The fishermen could not afford to gather the shellfish if landed prices were any lower. Retail prices for shellfish, on the basis of cost per pound, have been higher than those of fish, beef, pork, and poultry. Thus strong pressure exists in retail markets to reduce shellfish prices.

Another factor which suppresses the landed prices of shellfish involves sales to processing plants. Usually, fishermen have to sell their catch every day regardless of demand. Processing plants have to purchase the shellfish from them, even though their profit margins when selling them may be negligible. If the plant refuses to buy from the fishermen, it may lose them permanently as suppliers and thus have an inadequate supply to process or pack in forthcoming seasons.

Section III. Life Cycle, Factors Governing Abundance, and Abundance Fluctuations of Shellfish

The Life Cycle of Shellfish

The life cycle of shellfish involves a pelagic larval phase and a sedentary phase which assumes the adult shape. Shellfish spawn during the warmer months. Fertilization of eggs by sperm occurs externally. The larval period of shellfish varies by species. When salinities, temperatures, food, and other factors are close to ideal, oyster larvae develop to the settling stage in as little as 8 days, hard clam larvae in 6-8 days, soft clam larvae in 10 days and bay scallop larvae in 14 days (Loosanoff and Davis, 1963).

Oyster larvae have some control over their distribution in that the older larval stages can move up in the water during flood currents and down near the bottom during ebb currents, a feature which enables them to remain near oyster beds in estuaries (Nelson, 1912; Carriker, 1951; Kunkle, 1957; Haskin, 1964; Wood and Hargis, 1971). It has not been determined what features, if any, control the distributions of hard clam, soft clam, and bay scallop larvae.

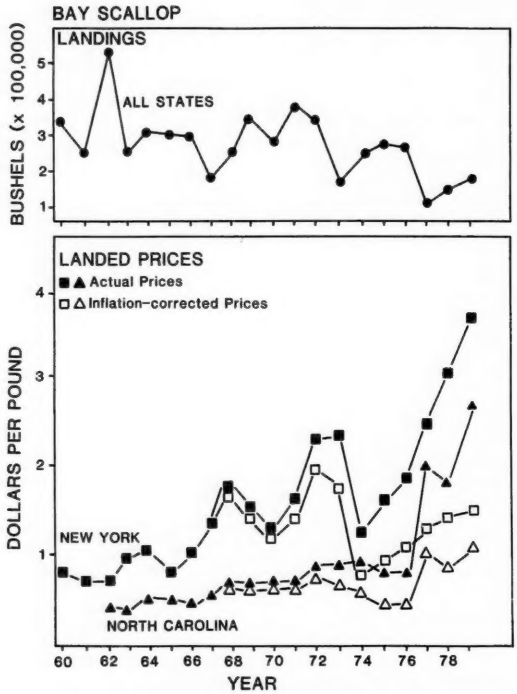

Figure 14.—Landings and prices of bay scallops, 1960-79. (Source: Anonymous, 1946-79.)

Larvae attach to available substrates, become seed, and grow. Normally, the substrates used by oysters are a live oyster, shell, or stone; hard clams and soft clams use sand grains, and scallops use blades of algae or grass, stones, or adult scallops. The bay scallop is the only one of the group which can "swim" as an adult. During the warmer months, its activity alternates between relatively long rests on the bottom and short "swims"; during winter, scallops are dormant and do not "swim." A new bed of shellfish can begin if larvae set beyond the existing beds and can survive and grow.

Factors Governing Shellfish Abundance

The factors that govern shellfish abundance are: 1) The biotic potential and environmental requirements of the shellfish as they interact with the condition of the water for supporting their larvae and the bottom for allowing settlement of the larvae and supporting the seed and 2) fishing effort on the shellfish stocks. Shellfish have a biotic potential sufficiently large to stock beds to excess, because each mature female produces millions of eggs, shellfish have high physiological survival, and as seed they grow rapidly. When conditions in the water are suitable, large numbers of larvae develop to the setting stage and, where the bottom is suitable for receiving them, they set densely but randomly on the beds.

Biologists do not know the minimum size of spawning stock needed to produce a commercial set of shellfish. One reason for this is that shellfish have never died out in any estuary which remained intact. Thus biologists have never had a chance to experiment with small quantities of adults to determine the number of seed which they could produce. It seems that: 1) The numbers of seed can vary considerably from one year to the next even when the numbers of adults are about constant (apparently, shellfish have evolved to produce irregular annual quantities of seed; this feature allows more seed to survive, because seed abundances are out of synchronization with predator abundances), 2) relatively large quantities of seed can result when the numbers of adults are relatively low, and 3) inversely, sparse sets can result when adults are abundant. In other words, the size of the spawning stock above some undetermined minimum seems to have much less importance than conditions in the water for survival of the larvae and seed production.

Loosanoff (1966) has reported that little relationship exists between the number of oyster seed produced and the size of the spawning stock in Connecticut. In 1958, for example, the oyster beds of Connecticut had a heavy oyster set when spawning stocks were at one of their lowest recorded sizes.

I have had the rare opportunity to witness recruitment of soft clams in an area previously devoid of that species and thus it is worth describing in detail. The area was Edgartown Great Pond on Martha's Vineyard, Mass. The pond has an irregular, somewhat circular shape and has about 24 km (15 miles) of shoreline. It is separated from the Atlantic Ocean by a barrier beach about 2.4 km (1.5 miles) long and 90 m (100 yards) wide. In 1950 the pond had been closed to the ocean for a number of years and had become fresh. It did not contain any soft clams. In the spring of 1951, the town of Edgartown opened the pond to the ocean by digging a ditch through the beach. The purpose was to make the pond salty enough to support commercial stocks of soft clams. The town opened the pond every spring thereafter; it remained open for about 2 weeks each time. In May of 1951, fishermen transplanted about 10 bushels of adult clams to the pond and spread them out in several locations, hoping that these would be sufficient to seed the pond. Within 2 years (i.e., by the fall of 1952) the fishermen found quantities of clam seed in most sections of the pond. The seed were sufficiently abundant to support

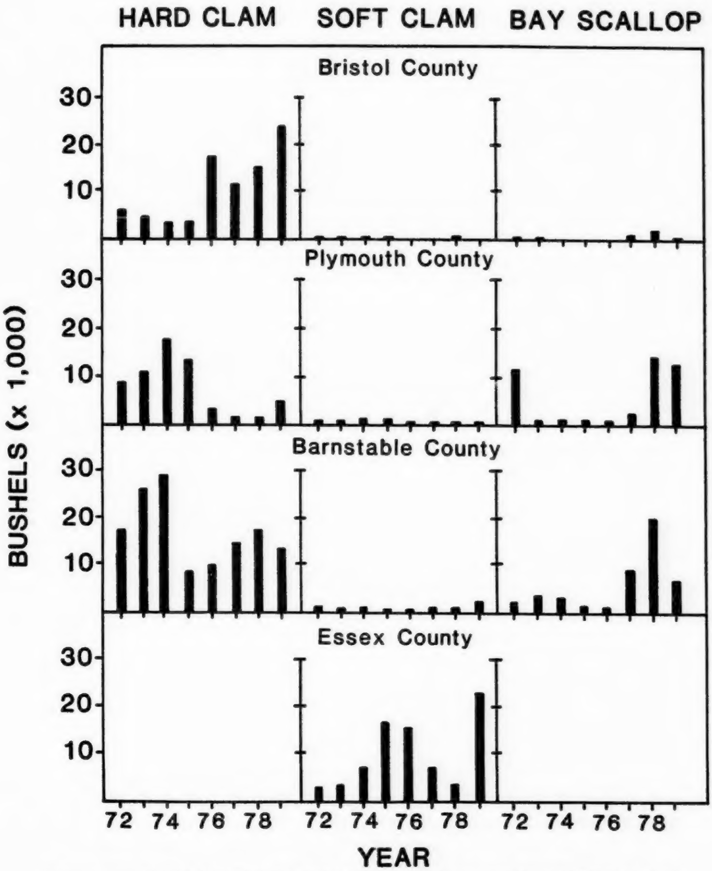

Figure 15.—Annual landings of hard clams, soft clams, and bay scallops in four counties in Massachusetts, 1972-79. (Source: Anonymous, 1946-79.)

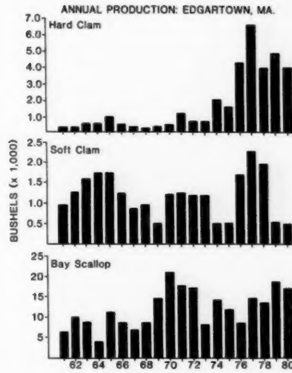

Figure 16.—Annual landings of hard clams, soft clams, and bay scallops in Edgartown, Mass., 1961-80. (Source: Town of Edgartown Annual Reports, 1961-80.)

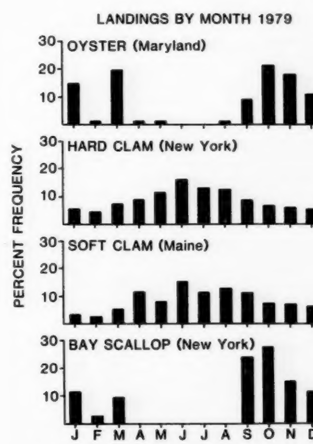

Figure 17.—Seasonal landings of oysters, hard clams, soft clams, and bay scallops. (Source: Anonymous, 1946-79.)

commercial fishing when they later attained market size. Presumably, the 10 bushels of clams produced many seed the first year, and, by the second year, these clams, which by then were mature, along with the older clams were sufficiently numerous to seed the entire pond. Apparently, wind-driven water currents distributed the clam larvae around the pond.

I have observed that the numbers of bay scallops produced is independent of the size of the spawning stock. In Edgartown, Mass., scallops in commercial quantities occur in five areas (three saltwater ponds, one bay, and an inner harbor). Four of the areas are well separated from one another, and it is unlikely that scallop larvae from one area seed any of the others. Scallop abundance fluctuates widely among the areas in any year. For instance, scallops may be abundant in one pond and scarce in the other areas in one year, and then scarce in the first pond and in scarce, moderate, or abundant supply in the others in the next year. Obviously, the quantity of seed and adult scallops produced has only a small dependence on the numbers of adults.

Because only relatively small stocks of adults seem to be needed to produce quantities of seed, it is logical that the most efficient way to produce more shellfish is by improving environments for ready-to-set larvae and shellfish seed. Increasing the size of the spawning stock without improving environments may have little effect. Moreover, when the seed are a year or two from reaching commercial size, they produce gametes; thus the more seed that are produced by means of environmental

improvement, the larger is the spawning stock.

Mortality of larvae and seed is much larger than in adults. The cause of larval mortalities are incompletely known, but it has been shown that predators cause most mortalities of seed. (See species profiles on the oyster by Stanley and Sellers, 1986; hard clam by Stanley, 1985; and soft clam by Abraham and Dillon, 1986). Mortalities of seed are high because a new generation of predators appears each summer simultaneously with each new generation of shellfish, both of which are then at peak abundance (Turner, 1953). Abundances of juvenile predators vary substantially among years. Juvenile gastropods, rock crabs, and starfish can feed on shellfish seed. In addition, adult predators select small seed over large seed when both are available and they consume them much faster than the larger ones. As they grow, the shellfish survivors become increasingly invulnerable to predation because the predators are not then sufficiently large to bore, crack, open, or swallow them. Table 2 lists some characteristics of common shellfish predators.

Much remains to be understood about the factors that limit setting and survival of larval and seed hard clams, soft clams, and bay scallops. Currently, little is known about: 1) The predators of larvae, 2) the effect that biota growing on and among sediments have in controlling the setting density of seed, 3) the magnitude of typical setting densities of clam and scallop seed, and 4) the predators of seed during the first several months after they set. Only speculative estimates have been made of the percentages of hard clam, soft clam, and scallop seed that attain commercial sizes. A study in Denmark showed that densities of bivalve seed ranged as high as 8,500/m, but mortalities from predation were nearly 100 percent in the first few months after they had set; presumably, some individuals of each species escaped predation, matured, spawned, and perpetuated the species (Muus, 1973). Perhaps, a similar pattern of relatively dense setting and heavy mortality from predation occurs in many hard clam, soft clam, and bay scallop beds in the eastern United States.

Heavy fishing on shellfish stocks can remove most legal-sized shellfish from beds, but I believe that it rarely reduces the size of the spawning stock to a point that too few seed are produced to perpetuate commercial-sized stocks. In marine finfisheries, which are all public, heavy fishing on stocks has occasionally led to their depletion. One reason for the depletion is that many immature fish are killed when caught inadvertently in trawls with marketable fish; heavy fishing often cuts deeply into the potential spawning stock and thus too few eggs are produced. Hardin (1968) has labelled such a depletion of fish a "tragedy of the commons." Only recently have restrictions on the quantities taken or the numbers of fishing boats in a fleet been made.

In the hard clam, soft clam and bay scallop fisheries, however, fishermen leave seed in the beds and they kill few seed. Moreover, limits are placed on the sizes and types of gear and the catches that can be taken to prevent depletion of adults. Finally, an adult female shellfish produces a great many more eggs than a female finfish. In the oyster fishery in some rivers, seed is taken from designated beds but enough remains for spawning. In some states, such as New Jersey, the quantities of oysters on beds are surveyed before a season opens and only a limited quantity can be removed by the fishermen. On market beds, all oysters less than 3 inches long have to be returned to the beds. The laws, passed during the early part of the century, are usually well enforced. These laws and the programs of spreading shells on oyster beds by states have usually prevented shellfish depletion by overgathering by fishermen.

Natural Fluctuations in Shellfish Abundance

Environmental changes are followed by changes in shellfish abundances. This section lists some examples.

Oyster

Abundance of the oyster has fluctuated widely in various estuaries in response to changes in environmental conditions. For instance, in Long Island Sound, storms and an irruption in the starfish population have substantially reduced oyster abundances. The largest storms were in the 1938 hurricane and a major easterly in November 1950. The starfish irrupted in 1957, remained abundant afterwards and destroyed nearly all seed oysters, crippling the industry. The industry did not recover until 1966 when starfish, oyster drills, and other causes of mortality were controlled by oyster companies (MacKenzie, 1981). In the James River, Va., large quantities of oysters, up to 90 percent on some beds, were killed in 1958 by freshwater flooding (Andrews et al., 1959). In Mississippi Sound, Hurricane Camille in 1969 damaged several oyster reefs, substantially reducing oyster production from them; one formerly productive reef of 400 hectares (1,000 acres) was covered by a mud deposit, about 5 cm (2 inches) deep, which left it barren of oysters (MacKenzie, 1977b).

A disease termed MSX (*Minchinia nelsoni*) developed in oysters in Delaware Bay and Virginia in the 1950's and crippled the oyster industries there. Oyster mortalities exceeded 95 percent annually in some blighted beds for several years (Haskin et al., 1966; Sindermann and Rosenfield, 1967; Andrews and Wood, 1967; Sindermann, 1968, 1976).

In the early 1970's, oyster abundance increased substantially in upper Delaware bay as a result of reduced salinities coupled with effective management by the Oyster Research Laboratory of Rutgers University, Port Norris, N.J. Fresh water killed the organisms that fouled oysters and shells, and thus oyster larvae could set in quantity on the shells. The laboratory recommended much reduced fishing on the beds to maintain the quantity of oysters and shells present.

Hard Clam

Two examples, one from Katama Bay, Martha's Vineyard, Mass., and one from Great South Bay, Long Island, N.Y., will be used as illustrations of natural fluctuations in the abundance of hard clams.

Katama Bay supported quantities of hard clams in the early 1900's (Belding, 1912) and through the mid 1930's. The

Bay is open to Vineyard Sound at its northern end and was separated from the ocean by a 4 km (2.5-mile) sandbar at its southern end. The 1938 hurricane, however, broke an opening in the barrier beach between the Bay and the Atlantic Ocean. Afterward, water currents were much stronger in the Bay and probably swept most hard clam larvae out to sea. Moreover, the currents washed sand over the beds and changed the bottom for hard clams from a favorable mud-sand to a less favorable coarse sand. The opening remained for a period of years. Hard clam abundance increased after the opening became narrow and decreased when it opened widely.

Production of hard clams in Great South Bay was low until the late 1930's (Wallace, 1971; McHugh, 1972). The Bay had a small opening which permitted little exchange of water with the ocean. A much larger opening broke through the barrier beach between the Bay and Atlantic Ocean during the 1938 hurricane; it remained and led to an increased exchange of water with the ocean. The result was a substantial improvement in the environment for hard clams, the opposite of the effect in Katama Bay. As a consequence, hard clams became abundant. Hard clam production rose sharply and was substantial through 1976; in fact, the Bay has produced about 45 percent of the hard clams landed in the United States in some years (Flagg and Malouf, 1983). Apparently, most larvae have been retained in the Bay since 1938.

Soft Clam

Soft clam abundance has fluctuated widely. In Maryland, when salinities are relatively low and summers are exceptionally hot, quantities of clams have been killed (Shaw and Hammons, 1974).

Green crabs can destroy nearly all soft clam seed in beds in some areas. Responding to trends in temperature of several years duration, the green crabs in New England fluctuate widely in abundance; when temperatures become warmer, the crabs become more abundant; when temperatures become cooler, the crabs become scarcer; when the crabs are scarce, the soft clams become abundant and vice versa (Glude, 1955; Welch, 1969). During the 1940's, soft clam production declined sharply and became low in Maine and Massachusetts; production remained low through the mid-1950's. The decline was caused by a sharp increase in numbers of the green crab, which destroyed virtually all soft clam seed (Glude, 1955). During the late 1950's, soft clam production rose again and remained sizeable at least through the late 1960's, because the green crab had become scarce (Welch, 1969).

Bay Scallop

The abundance of bay scallops is influenced by the presence of eelgrass in most localities. Scallops are much more abundant in relatively large bays if eelgrass beds are present. On the other hand, in small bays and ponds, the presence of dense eelgrass beds seems to substantially reduce scallop abundance, perhaps because water circulation is sharply curbed. The scallop distribution was different around Martha's Vineyard prior to the mid 1930's than it has been since. Before the eelgrass dieoff in the mid 1930's along the Atlantic coast, the plant was distributed on shallow bottoms a kilometer (about a mile) beyond the entrances of salt water ponds. Scallops grew there also, and were most abundant in "hogbeds" (small open areas within dense stands). After the eelgrass died, scallops disappeared from areas outside ponds.

In the relatively large bays of North Carolina, bay scallops are much more abundant where eelgrass is present than where it is scarce; the environment where eelgrass is absent will not support many scallops (Kirby-Smith, 1970). Thayer and Stuart (1974) found that where scallop fishermen had uprooted and removed most eelgrass, it did not regrow and was sparse during the next bay scallop setting season; consequently, scallops were scarce in the dredged areas a year or more after the dredging.

In the Niantic River, a relatively small estuary in Connecticut, the bay scallop population was sparse when eelgrass was abundant before the 1930's. When the eelgrass disappeared in the early 1930's the scallops became abundant (Marshall, 1947, 1960). Eelgrass reappeared, covered large areas and became dense during the 1960's. It slowed water currents and made the bottom muddy. Consequently, the environment worsened for scallops and they became scarce again.

Section IV. Characteristics of Shellfisheries and Shellfishermen of Eastern North America

This description of shellfisheries is based on my observations in Massachusetts, Connecticut, Maryland, Virginia, Mississippi, and Prince Edward Island. It may not apply to every locality in the eastern United States because shellfisheries vary in size and species among states, counties, towns, and also rivers, ponds, coves, and beds within a county or town. Each locality also has a unique economic and cultural situation, and local attitudes towards shellfish management differ.

A number of myths and misunderstandings have accumulated about fishermen which mask and distort the real problems and tend to mislead policymakers. Traditional shellfisheries are not wholly static. It is untrue that public beds yield far less than private beds acre for acre. The sometimes criticized fisherman is actually an honorable man who works hard to produce shellfish for people to consume. The fisherman is extremely pragmatic and commercial in outlook. He is efficient in using the gear which he has at his disposal. A fisherman has a perfectly plausible justification for whatever he does and he also has the facts and figures of his operation at his fingertips. He is strongly conservation-minded toward shellfish. He is also responsive to better gear and methods and will adopt them if he can.

Usually, shellfisheries exist in a small town or rural area, which is characterized by stability and simple virtues, such as hard work and thrift. In most localities, any local or state resident can purchase a license to gather shellfish commercially from public beds. In some localities, state and local regulations allow gathering only during specified seasons, and they may limit the daily catch. The purpose of the regulations is to conserve shellfish stocks, ensure

future yields, and to spread out and maximize employment and earnings. Often the towns in Massachusetts adjust any opening and closing dates of seasons, such as for the bay scallop in the fall, to conicide with the time when other seasonal employment ashore slackens. Communities often provide free dock space for the fishermen's boats.

People in local communities have positive attitudes towards shellfisheries. The attitudes stem mostly from the economic wealth which the beds provide, but also from basic instincts of wanting to have living wild resources maintained, and because shellfish are a food. Local people know the fishermen and the names of the important beds and are usually aware of the current supplies of shellfish on the beds. Many people are curious about the yields of shellfish landed and the money earned by fishermen. Shellfish are a tourist attraction for local restaurants.

The daily activities of shellfishermen are scarcely known to the local community, except through social contact with fishermen ashore. This is because: 1) Fishermen usually leave the shore at first daylight and return with their shellfish in mid-afternoon, a time when most people would not see them, and 2) the beds may not be visible from shore roads.

Shellfish beds are owned by the state or, in some instances, the local town. These entities manage the public beds by allowing fishermen access to them during certain seasons and regulating the quantities of shellfish which can be taken. Nearly all beds that are leased to private individuals are also owned by the state or town. Leased beds can be used only for raising shellfish, i.e., the leaseholder can neither mine sand, gravel, or other material, nor add fill to the beds. Some of the descriptive material presented in the following section also applies to leaseholders and private companies.

Description of Public Shellfisheries

The working life of a shellfisherman is characterized by seasonal gathering of bivalves in the beds, with alternate employment ashore, or fishing for other species such as crabs, lobsters, or finfish. In a sense, shellfishermen are similar to family farmers: Fishermen work on the beds for several months a year gathering shellfish as farmers are in the fields planting, cultivating, and harvesting field crops. Similarly, fishermen have an autonomous and free working style within the limits of legal regulations.

The condition of low and uncertain abundance often dominates the working atmosphere of the hard clam, soft clam, and bay scallop fisheries. The clams may be scarce for years, whereas bay scallop abundance varies widely among years. When shellfish are scarce, conditions of life are usually hard for fishermen and their families. Depression, fostered by the poor economic situation, is rampant. On the other hand, relatively high shellfish abundance on beds translates into nearly full employment and brisk economic activity. When times are good, people are optimistic and happy and they have more economic freedom. Some economic levelling occurs because usually when shellfish are scarce, prices are up, whereas when they are abundant, prices are down.

Conversations among fishermen reflect their concerns about low or declining shellfish abundance and incomes. The topics may include: 1) Where shellfish are most abundant, 2) the quantity, quality, and value of one another's take, 3) how much shellfish seed they see, 4) costs of gear, 5) the current shellfish price, 6) effectiveness of a new variation in gear, and 7) how any recent change in the environment will affect shellfish abundance.

The system of public shellfisheries features the greatest good for the greatest number of people. As an entity, the system has several positive features and a few negative features.

The advantages of the system for communities are:

1) The system features relatively large employment for fishermen on the beds.

2) It features about equal incomes among fishermen.

3) It is a safeguard against unemployment assistance payments by providing jobs when no others are available.

4) It supports local businesses such as shellfish processing plants, shipyards, blacksmiths, hardware stores, and fuel suppliers.

The advantages of the system for fishermen are:

1) It allows the fishermen to earn a living while working for themselves.

2) It allows the fishermen to get paid commensurately with what they produce, which means that they have maximum incentive to work hard.

A disadvantage of the system is that there is easy entry into the fishery. The consequences are: 1) More competition than usual for the shellfish, 2) smaller than usual landings and earnings for each fisherman, and 3) earlier than usual depletion of the shellfish. The regular fishermen usually resent the irregular fishermen, whom they call "fly-by-nighters" or "moonlighters," because the "cream" of the shellfish is removed earlier in the season.

Another disadvantage is that it may be difficult to obtain a consensus of opinion about cultivating the shellfish beds or making a change to a slightly different management system from the fishermen and the people of a community. Almost everyone is afraid that someone else is going to get ahead of them in the new system, so they are hesitant to approve it. In addition, the community has to pay for any shellfish cultivation projects; if the beds were privately owned, companies would pay for the projects.

In places where the public shellfishery is relatively large, the local community gains considerable economic benefit from it. The value of a shellfishery is much higher than the direct employment which it provides on the beds because fishermens' earnings are multiplied through the economy; the total value of the shellfish in the various localities where they are landed and consumed is two to four times the landed value (Callaghan and Comerford, 1978; Coastal Zone Resources Corporation[1];

[1]Coastal Zone Resources Corporation. 1972. The economic impact of commercial sports fishing activities in Morehead City, N.C. Unpubl. rep. prep. for N.C. Dep. Admin., 178 p.

Wong [2]). Currently, the only overhead cost of a shellfishery to the local community is the salaries of wardens, and these are mostly paid for by the license fees from the fishermen. The shellfish reproduce and grow naturally at no cost, except in the oyster fishery in some localities where shells are spread and seed is transplanted by public agencies on public beds.

Communities may suffer during periods when shellfish are unusually scarce on their beds:

1) Employment is low and uncertain among fishermen and workers in processing plants; economic activity in shellfishing communities is much reduced. The fishermen feel demoralized.

2) Boats, processing plants, and trucks operate well below capacity. Because costs of labor, fuel, and other overhead remain about the same regardless of shellfish production, the profit from each unit quantity of shellfish is much reduced.

3) In retail stores and restaurants, shellfish are less available and prices are higher. It takes years for shellfish to become established at a certain price in the market. When shellfish become scarce, consumers will substitute other foods for shellfish. When the shellfish again become abundant, the market must be redeveloped.

4) Some public fishermen may poach shellfish from private leases, resulting in confrontation between the fishermen and leaseholders.

5) Some public fishermen may try to poach shellfish from polluted beds which have been legally closed. The activity results in public health problems, confrontation with the police, and caution by the consumer in eating shellfish.

6) The regular fishermen feel more resentment than usual toward newcomers to the fleet, such as college students earning money by clamming during summer vacations.

7) The older fishermen feel that they are aging faster than normally when shellfish catches are declining.

[2]Wong, E. F. M. 1968. A multiplier for computing the value of shellfish. U.S. Dep. Inter., Fed. Water Pollut. Control Admin., New Engl. Basins Off., Needham Heights, Mass. Unpubl. rep., 14 p.

When shellfish become less available, communities hope that public agencies will be able to bring about an increase in shellfish abundance and production and also reduce pollution. They hope that public shellfisheries will grow. For example, a man about 70 years old in Prince Edward Island told me that before he died he wanted to see oysters come back in Malpeque Bay, where they had flourished a number of years previously but had since been killed by a disease.

Additional features of public shellfisheries are listed below.

Shellfish Production System

Shellfish production systems comprise a number of components. The largest is the group of fishermen who gather shellfish from the beds. Next is the processing (packing) houses where shellfish are shucked (oyster, bay scallop, and sometimes the soft clam), steamed open (oyster), or packed whole (oyster, hard clam, and soft clam) for sale to wholesalers. Wholesale houses distribute them to retail stores and restaurants for sale to consumers. Another component is the trucks which transport shellfish from the packing houses to wholesale houses, stores, and restaurants. Usually, within any component, individuals have knowledge of the immediate people and functions with which they deal, but little knowledge of other sectors. The public fishermen know the processors, but not the wholesalers, retailers, and customers; processors know the fishermen and wholesalers but not the retailers and customers; wholesalers know the processors and retailers but not the fishermen and customers; retailers know the wholesalers and customers but not anyone else; and customers interact only with retailers.

Shellfishing Equipment

Fishermen use tongs, rakes, dredges, hydraulic escalators, and nets from their boats, and hoes or rakes on tidal flats, to gather shellfish. Some fishermen have one or more mates (crewmen) on their boats. Usually the best fishermen have the best boats, equipment, and mates. The oyster is gathered with tongs and dredges; the hard clam mostly with rakes, but also with tongs and the escalator harvester. The soft clam is gathered from flats with a hoe or by wading in shallow water with a combination of churning hoe and rake, by hydraulic jet used with a rake, and by the hydraulic escalator harvester. The bay scallop is gathered primarily with dredges (usually called drags in New England) but also with dip nets. Some of the basic equipment designs were brought over from Europe by immigrants during colonial times.

Shellfishing Fleet and Crews

A fleet is composed of boats operated by men who range widely in age. Some men spend nearly their entire working lives as fishermen, starting their careers as teenagers, then becoming regular or mainline fishermen, and finally "old-timers." Some men started in shellfishing because it was the highest paying job available; others were attracted by the independence associated with it. The best fishermen gather the most shellfish per day as a function of strength, skill, and incentive, or they have a shorter day on the water if a catch limit exists. The least experienced fishermen take fewer shellfish because there is a learning curve on gear use and efficient techniques for particular beds.

Some fishermen in a fleet exhibit competitive behavior. An informal ranking of fishermen may be present based on: 1) Size and quality of boat, 2) daily shellfish take, 3) ability to gather shellfish in quantity when others cannot, i.e., when shellfish become scarce or during adverse weather, and 4) whether a fisherman is a finder or a follower. Status, which is commonly known in the local community, is based on the ranking and can be a main source of fisherman and family pride. A fisherman may not be able to raise his rank without an immediate response to increase landings from those above him. Often, competition is on a daily basis.

Fishermen often have group loyalty. They wonder how good a recruit to the fishery will become and they hope that an old-timer can remain fishing.

Fishermen are independent, nevertheless, and do not easily form into special interest groups even for their mutual

benefit. When government bodies have tried to form fishermen's associations, usually they have had difficulty. Normally, association meetings are poorly attended. At public meetings held to discuss matters relating to shellfisheries, fishermen voice disparate, rather than joint, opinions.

Poaching

Some fleets have a small number of poachers who will illegally take: 1) More shellfish from beds than regulations allow, 2) shellfish from leased beds or oysters from beds with dredges when only tonging is allowed, and 3) shellfish from polluted beds which are legally closed. Most poaching is done at night. Poachers rationalize that their actions are not crimes because shellfish occur naturally or that polluted shellfish are not actually polluted. Poaching is considered as a much smaller crime than stealing goods ashore. Law-abiding fishermen rarely reveal the actions of a poacher to wardens, but they strongly resent them.

Shellfishing Season

When a new season begins, the fleet fans out over the beds to sample them for shellfish abundance and quality, usually with some prior knowledge from the previous season. They begin gathering on the beds which have the most abundant supplies. Each day thereafter, fishermen head for the best beds or "spots" and, as a season progresses, the shellfish supply diminishes. Usually, shellfish seasons last 2-6 months, and they vary in terms of available shellfish quantities and prices. A boom, or bonanza, season is characterized by a large supply coupled with good prices.

A fisherman's judgment about the quantities of shellfish available in a season can be strongly colored by the relative number of competitive fishermen in the fleet and his individual catch rate. Thus in a season of low supply and few fishermen, a fisherman may believe that the supply was average because the shellfish quantities available to him were average. In a similar season, had the number of fishermen been larger, the fishermen would believe that the shellfish were scarce.

Typical Shellfishing Day

Most of the day is spent making dips with gear gathering shellfish. An oyster tonger usually makes a few score dips a day and an oyster dredger tows his dredges over a bed and hauls them in many times during a day. Sometimes, fishermen spend 6-7 hours on the water and a few extra hours getting the catch to buyers or repairing equipment for the next day. Hard clammers, soft clammers, and bay scallopers often work shorter days on the water. A day's activity constitutes a race with time to gather enough shellfish to earn a day's pay. No guarantee exists that the shellfisherman will be successful, e.g., the spot may have a few shellfish remaining and time is lost while finding another good spot; the weather may be bad; or the gear may break down forcing the fishermen to return to shore for repairs which may take a day or more. When a day's take is large, the day seems short and fishermen feel satisfied; if small, the day is discouraging, monotonous, and long. When fishermen return to shore with their catch, they sell it to a processor who pays each day or week. Often, bay scallopers shuck their own scallops before selling them. The fishermen who have to gather shellfish during periods of low tide, i.e., some oyster, hard clam, and soft clam fishermen, have irregular working hours, because the tide advances approximately one hour later each day. Thus, they may work in the morning one week, in the afternoon the following week. Late in the second week, the tide might be low enough to enable them to work only early in the morning and late in the afternoon.

Relative Earnings

As noted, earnings are roughly equal among fishermen on the beds; they are not as polarized as they are in many occupations ashore. Normally, however, the better fishermen tend to gather the highest quality of shellfish and will earn the most money, while the poorer fishermen gather the most abundant shellfish which may be the least valuable and thus earn less money.

The poorest fishermen are sometimes accused of being indolent, finding excuses for missing a day of work, keeping their equipment in poor condition, gathering the most abundant but often least valuable shellfish to finish sooner, and spending money on alcoholic drinks rather than food. The criticisms have some validity, but an examination of each situation usually reveals that the fishermen may be getting the most from their circumstances, which all too often is characterized by low personal strength and vigor and poor skills, along with scarce shellfish supplies on beds. The poorest fishermen quickly reach a point of diminishing returns if they try to keep pace with the better fishermen.

Fishermen's earnings are limited because: 1) Shellfish supplies may be inadequate for the number of fishermen; 2) much time is lost due to bad weather, broken gear, and closed seasons, and 3) expenses take a substantial portion of gross incomes. For example, in Prince Edward Island, expenses for gear alone for oyster fishermen totalled about 20 percent of weekly earnings; total expenses of fishermen who lived away from home in trailers during the week totalled about 35 percent of weekly earnings (MacKenzie, 1975). A number of fishermen have told me: "The secret of staying in this business is to keep your expenses down".

Economic Status of Fishermen

Public fishermen have about equal economic status with most craftsmen working ashore. They lose some self esteem whenever shellfish become scarce and they have to search for jobs ashore. Most fishermen always consider themselves as fishermen; any other jobs are part-time jobs.

Security of Fishermen

As noted, most fishermen depend entirely upon the "mercy of nature" to provide shellfish in the beds. Fishermen are commonly haunted by insecurity, because they fear that shellfish supplies will soon be depleted. Insecurity seems to be most serious among the hard clam fishermen because they rarely see the small clam seed in the beds. Thus they often fear that few exist. Fishermen also

live with the pessimism that shellfish may never spawn again.

Lack of an Employment Ladder

A structured way of advancing in a career barely exists in shellfisheries. The mate on a boat may be able to obtain his own boat, but rarely does a boat owner become a packer (processor). Nearly all fishermen who obtain their own boats by their 20's remain at the same position throughout their working years. They learn how to gather shellfish efficiently from each bed within 2-3 years and learn how to save steps over the years. They lose strength and taper off in the amount they can gather and earn as they age.

Little Alternative Employment

Many fishermen tend to remain on the beds trying to make a living during lean economic periods, and lay people wonder why they persist. The answer is that any work available ashore is perceived to be a worse alternative. The fishermen remain on the beds because: 1) They are physically and mentally adjusted to fishing (they are used to irregular hours); 2) if they had been brought into shellfishing by a favorite relative, such as their father, they feel bound to do the things he had taught them; 3) they do not want to sell the boat they may have worked to obtain or acquired from a relative; 4) if they took a job ashore, they would lose their autonomy and independence (a psychologically stressful solution); 5) they know the shellfishing business, but they do not know other jobs well and therefore feel uneasy in them; 6) shellfishing has little or no paperwork, and most fishermen resent paperwork in another job; and 7) fishermen simply enjoy the solitude on the water. I asked a soft clam fisherman in Maryland if he would rather work on the beds or work ashore (as a carpenter's helper). He said: "I would much rather fish for clams. I don't like being hollered at when I work ashore."

When people have to move to another job with lower position and pay or to unemployment, the following conditions usually result: Psychological depression, reduced medical care, reduced nutrition, and possibly an increase in the consumption of alcohol. It produces strains on people's families: Wives find that they have to manage with less and may have to find a job to help support the family. Such events are common among shellfishing families during periods of shellfish scarcity. Many young fishermen have been forced to leave their communities to find work in cities during those periods.

Freedom of Fishermen

Each fisherman has the autonomy and independence of someone owning his own business. He owns his boat and equipment, he controls his time, he gathers on the beds which he chooses, and makes numerous daily choices within the limits imposed by nature, legal regulations, and the market.

Satisfactions of Fishermen

When their earnings are adequate, fishermen are among the most satisfied workers, because they have a high level of personal control over their work and close ties with their product. Fishermen enjoy the peacefulness and beauty of the water and shorelines. Working in harmony with nature to supply food for humans fosters positive human emotions. The old-timers benefit from fishing by satisfying the need to be engaged in constructive physical activity.

Fishermen's Attitudes Toward Shellfish Resources

Of any concerned group, the fishermen have the largest stake in the welfare of the beds and conservation of the shellfish. Thus, contrary to some beliefs, fishermen have a strongly protective attitude towards the beds and shellfish. Whenever possible, fishermen return oyster shells (even when not required by law), destroy the predators which they have gathered, and will leave beds alone where seed is abundant so as not to damage them.

Fishermen have been accused of "not caring about tomorrow," because they sometimes take too many shellfish from a bed, especially if a new stock is discovered. The accusation is nearly always unfair. The fisherman took them because he feared the shellfish would be gone if he left them. He has no way to reserve the shellfish for himself.

Attachment of Fishermen to the Beds

Fishermen develop a psychological attachment to the shellfish beds, similar to that of farmers with their land, because the beds are the primary source of their livelihood. Usually, fishermen have pride in their local beds, believing them to be especially productive and believing the local shellfish to be a unique and superior "strain" or having a superior quality.

Efficiency of Fishermen

Fishermen possess the same characteristics that Schultz (1976) has described for farmers: They 1) allocate their resources efficiently, 2) have strong incentives to hit margins, 3) respond to incentives, and 4) do the best possible with the resources at hand. Fishermen make efficient use of their boats, equipment, fuel, time, money, and strength in gathering shellfish. In analyzing the operations of fishermen in several localities, I have not seen where efficiency could have been substantially increased. The equipment and methods for gathering shellfish, which were developed by trial and error, have been refined and sharpened by many years of experience; each generation has had its experimenters, who added a bit here and improved a practice there. In most locations, the equipment is restricted by law. Fishermen's actions are not always wholly governed by an orthodox, profit-maximizing rationality. Sometimes, private lives are given consideration over work and fishermen may prefer to use a slightly less efficient method passed on by a favorite relative or other teacher.

Knowledge of Fishermen

Fishermen have much more knowledge about factors relating to shellfishing than most people suspect. They have a broad knowledge of vessel and equipment operations and repair, the location of beds, efficient gathering techniques for each bed, laws relating to shellfish gathering, economics within the fishery, weather forecasting, and the life cycle of shellfish. Fishermen learn much of

this as children and teenagers and during their first few months on the beds. They do most of their own mechanical and repair work on their gear and boats. They have some knowledge of how the effects of weather, an opening between a bay and the ocean, freshwater flooding, and similar phenomena affect shellfish abundance.

What Fishermen Do Not Know

Fishermen have little knowledge about some of the critical factors that limit shellfish abundance, because they cannot see the bottom. Oyster fishermen do not know the condition of the bottom for receiving sets of seed and much shellfish mortality is never seen because principally small seed are consumed by predators. The fishermen do not know the density of the initial set of seed shellfish, especially in the hard clam and bay scallop, nor do they know what kills the seed, what percentage of the initial set is lost before they gather the adults, or what opportunities may exist for reducing mortality.

Myth of the Intractable Fishermen

Fishermen have been considered pillars of tradition: Men tied closely to history and unwilling to improve their gear or procedures. However, the belief is largely a myth. In actuality, fishermen have almost always looked for ways to improve their efficiency in gathering shellfish. Fishermen will use better methods that one of them or someone else develops if they can. As we have seen, fishermen try to obtain as much as possible each day, consistently striving to turn an extra dollar and, over the long haul, to gain more money and security. Thus the more progressive fishermen do try to devise new methods to increase their catches and efficiency.

When a fisherman tries a new method, the others watch, and they will adopt and try to improve upon it if it is better than the one they had been using. It is ironic that the original inventor often has the least efficient model of his new method after the remainder of the fleet has copied and improved it. When interviewing fishermen, I have received the impression that they are eager to test any method which has the slightest chance of helping them. I believe that fishermen are no more intractable than people in other occupations. The pessimism about the intractability of fishermen is unwarranted and thus the myth needs to be set aside.

Fishermen cling to traditional methods because they provide the safest assurance of a livelihood. The economics of shellfishing allows little margin for risk and thus fishermen are extremely hesitant to assume the risk of innovations, especially if their advantages over traditional methods are uncertain. When fishermen reject innovations, they rationally weigh the likely changes in incomes and risks associated with the innovations and decide for them that the innovations do not pay.

A glance at agricultural history sheds light on the situation. For a long period, farmers did not adopt many suggestions being made to them. As a consequence, the belief arose among scientists and lay people that farmers in the United States and throughout the world were bound by long years of tradition and thus could not adopt any new methods. It was not until 1964 that an analysis of the apparent intractability of farmers was made in a book entitled "Transforming Traditional Agriculture" by T. W. Schultz (1976). He said that lay people knew surprisingly little about the economics of farming and explained that the main reason for the low rate of acceptance of new methods was that each farmer was locked into a tight, static economic and working situation, which had little margin for innovation; any risks were out of the question. A critical feature of traditional farming was that the rate of return to investment was extremely low.

Another reason for the slow adoption was that much of the information which farmers had received was not applicable, at least not immediately, and thus did not represent better alternatives to existing practices. Schultz said that to transform traditional agriculture, a more profitable set of production factors—more productive technologies and knowledge—had to be supplied to farmers. He argued that farmers do the best possible with the resources at hand and they respond efficiently to new production opportunities. He added that commanding farmers to increase production is doomed to failure even though they have access to knowledge.

Schultz (1976) provided a series of examples from farming communities throughout the world in which modern farming practices have developed in the place of ancient ones, thereby proving that farmers are not universally intractable. Since Schultz's book, Mellor (1966), Stevens (1977), Galbraith (1979) and others have reinforced and amplified these findings. A point which they emphasize about adoption of new methods is that yield is the bottom line for farmers: Without a guaranteed yield bonus from the use of a new method, with exceptions for bad weather, most farmers will not change traditional methods. Galbraith (1979) stated that the risk for the farmer of using something new is always higher than for the expert who recommends it.

In the past, scientists have given fishermen numerous suggestions to improve aspects of their work, but all except a few have been ignored. The scientists have concluded that fishermen will not accept sound advice.

After gaining an understanding of how the oyster fisheries functioned in Long Island Sound and Prince Edward Island, I analyzed many of the earlier recommendations that had been made to improve them. I concluded that the fishermen had been correct to ignore those that had been ignored; most would have been harmful to the company or fishermen had they tried to use them. The companies and fishermen would have been faced with: 1) High initial costs, 2) sometimes extensive development on their part before the suggested methods could be used, 3) no real benefits, and 4) sometimes harm.

In reality, the scientists were aware of only some of the factors relating to the working life of the fishermen and thus were naive in believing that the suggestions were useful. In my experience with oyster companies in Long Island Sound, I followed the courses of methods which I had suggested to them and tried to analyze why some were ignored. The answer was that they would not have had any long-term benefit.

Power of Fishermen

Fishermen have little or no power over: 2) The costs of their equipment, fuel, and licenses, 2) the various human impacts that can degrade the shellfish environment, 3) where a pollution outlet is placed, and 4) the prices which they receive for shellfish. Fishermen have become used to changes for the worse, knowing they cannot correct them. They can modify specifics about the gathering regulations, such as the opening date of a season, by appealing to public officials.

Public fishermen do not have the power to direct their fellows to cultivate the beds for the purpose of increasing shellfish abundance. The problem is that all the fishermen will not donate their effort equally to the work. The ones who would otherwise be willing to do the work are reluctant to do so when those who are not would be able to share the benefits.

Fishermen have demonstrated the power to question seriously and then halt or substantially modify proposed programs to culture oyster beds for the purpose of increasing oyster abundance. If they believed that such a program might harm the beds or reduce shellfish abundance, they have voiced strong objections to it, in the meantime gaining support within the community. Politicians listen to the fishermen because if they implement an unpopular program, especially if it turns out to be unsuccessful, popular sentiment could turn against them. At times, fishermen have obtained the support of politicians and have forced fishery administrators to modify rulings.

Behavior of Fishermen at Meetings

In many localities, fishermen meet with fishery administrators perhaps only once a year to discuss important issues. Any contacts between the two entities in the interim are few and distant. Most of the time, much less is accomplished at these meetings than is promised because the fishermen express their views on issues haphazardly and there is little agreement among them on the important issues of the meeting. Sometimes the fishermen are loud, vehement, and even abusive to the administrators. They express their anger and frustrations about a variety of issues. Fishermen say anything they wish; because the administrators have no means to get back at them, the fishermen have little to lose. The result is that the administrators try to maintain distance from the fishermen until the next meeting, and the issues drag along without resolution. Not only is this situation counterproductive to shellfish enhancement, but it has a tendency to build barriers which impede any efforts to develop better working relationships.

Needs of Fishermen

Fishermen want to improve their economic situation without giving up the good aspects of their working lives. They want enhanced security, some measure of prosperity and the prospects of a better life for their children. They believe that more shellfish on the beds and good market demand and prices for their shellfish would assure this.

Attitude of Fishermen and Communities Toward Various Management Proposals Relating to Public Beds

Through the years, many fishermen and local communities have heard a number of proposals from governmental agencies and scientists for managing shellfisheries. This section describes three of the most common proposals for enhancing or conserving shellfish stocks and discusses common reactions of fishermen and communities to them:

Shellfish Enhancement Programs

Programs to enhance shellfish abundance are what the fishermen and communities everywhere desire. Such programs are discussed at length in the main body of this guide. The fishermen, by themselves, cannot effectively develop methods to increase shellfish abundance in public beds, however, because: 1) They know only a little about how environmental factors limit shellfish abundance (fishermen do not examine beds with scuba gear in most localities), 2) they do not have the training, 3) they have not received ideas and seen methods used in other locations since they travel little, and 4) since they are under severe economic stress to meet their financial needs, they have little spare time or money to try to increase abundance.

Increased Restrictions on Gathering Rates

McHugh and MacMillan[3] believe that hard clams and presumably other types of shellfish should be managed under the classical fishery management scheme, in which catch rates by fishermen are controlled. The fishing effort allowed is determined by the number of marketable shellfish recruited into the population: Fishermen cannot take more shellfish than are being recruited. In using the scheme, the following five basic estimates are needed: 1) The size of the standing crop, 2) the annual magnitude of recruitment, 3) the annual growth rate, 4) the annual mortality rate from natural causes, and 5) the annual catch rate by shellfishermen. With such information in hand, a manager can judge how many shellfish can be taken from the beds without substantially reducing the size of the population.

The fault with the scheme is that it does not include increasing shellfish abundance by using such procedures as improving shellfish environments or transplanting shellfish from overpopulated to underpopulated beds. In situations in which populations are declining as a consequence of adverse environmental conditions, managers can only recommend that catch be reduced to try to stop further declines. The fisheries management scheme has been used in managing finfish, especially those in waters of the continental shelf, where methods have not been developed to increase the abundance of fish stocks. It has been successful to an extent in managing public oyster beds, such as those in New Jersey where oystermen are allowed to take only a specified portion of the oysters from beds; surveys of the oyster populations are made before the oyster season opens. In New Jersey,

[3]McHugh, J. L., and R. B. MacMillan. 1976. Comprehensive report on the hard clam (*Mercenaria mercenaria*) industry in New York state. Coll. Mar. Stud., Univ. Del., Unpubl. rep., 57 p.

shelling of the beds to enhance the quantity of seed also takes place in some years.

A regulation to reduce catch is counterproductive to the needs of fishermen and local people, since they want to gather more shellfish to increase their incomes. Accordingly, such a regulation will generate much hostility among them, the people who formulate and apply the regulations will be judged as against the fishermen, and the fishermen will be against the regulations.

Leasing of Public Shellfish Beds

I have interviewed numerous public fishermen and local people in communities along the Atlantic coast. They were all strongly opposed to the leasing of any productive public beds to private comapnies who would use them for their own interests. Public fishermen are opposed to surrendering public beds (Walford, 1945) because the shellfish which the beds yield have considerable value. The fishermen would be deprived of employment, earnings, and freedom. A statement which fishermen commonly make is: "If they lease the beds, I will have to work for someone else instead of myself." Local communities oppose the leasing of public bottoms because large numbers of jobs and considerable money would be lost. Another disadvantage is that large companies using the most efficient, labor-saving technologies available to rear and gather the shellfish would hire only a small fraction of the people who normally work in the public fishery. Next, a company would retain almost all profits with little going to the community, especially if it were not owned locally. In sum, extensive leasing of public bottoms would translate into a force of displaced and unemployed fishermen, fishermen-laborers working for companies, strongly polarized incomes and much less wealth for the community. Although companies might be able to increase and stabilize shellfish supplies to the public, they could also raise prices when they desire.

In many localities, fishermen and local people will allow previously unproductive bottoms to be leased for the purpose of raising shellfish. Such leasing can create more employment and earnings for the community.

Description of Leaseholders and Companies

As noted, coastal communities have usually insisted that the beds which naturally produce shellfish remain public. If someone wishes to cultivate oysters, he may be able to lease bottoms that are, or nearly always have been, barren of shellfish. Private leases, common in most oyster states, allow individuals or companies to grow seed obtained from public beds to market size and sell them. On private leases from New Jersey southward, growers do not cultivate or improve the condition of the beds in any way before or after seed oysters have been planted on them. Many oyster growers do spread shells on their beds, however, to collect seed oysters. The private leases in some states provide a market for the seed oysters on public beds, which are otherwise nearly unsalable because they are too small. The private oyster beds in Long Island Sound have to be cultivated because otherwise the wild habitat would not support oysters because fouling organisms on shells and predators are too abundant in the relatively high salinity (25-27‰).

On oyster leases, the return for effort is much larger than in public fisheries because companies use relatively large boats which have mechanized equipment for transplanting and harvesting. As a comparison, in a 4-hour period, a typical boat can gather from a well-stocked bed as much as 2,000 bushels of oysters, while a hand tonger can gather about 40 bushels of oysters. Annual incomes of company owners are usually much larger than for fishermen on public beds. In Long Island Sound, the costs of oyster cultivation are borne by companies and they reap the benefits. Other outlays by companies include their payroll, taxes, insurance and maintenance of vessels, buildings and wharves.

The private companies of Long Island Sound prepare seed beds by spreading shells (500-2,000 bushels/acre) to collect seed oysters. The best seed beds have a potential for receiving a set about 2 out of 5 years (MacKenzie, 1981). At first glance, the risk may seem poor, but the cost of shelling a bed is relatively low compared with the value of oyster seed. If there has been a set, the seed oysters are transplanted during the following spring to beds which are relatively safe from storms and where they will grow well. Seed oysters are spread at densities which provide the least expensive protection and occupy the optimum amount of space, usually about 750 bushels/acre. The oysters are normally transplanted once a year to break apart clusters and spread them out as they grow. Oysters are grown to specific sizes for which the demand is largest and sold when the market demand is at a peak in the fall and early winter. If prices are low, oysters can be left on the bottom at negligible cost. The private companies produce oysters on bottoms which would be otherwise unproductive and provide jobs and monetary benefits which a typical business provides for the local communities.

Where leasing is practiced, an oyster or hard clam fisherman, who relays shellfish onto his lease, becomes more of a small businessman. He can retain oysters or clams on his lease when the market is glutted or the price is down and then sell them when the price is higher.

One inherent disadvantage of shellfish leases is that unless the lease is "worked" it remains unproductive. This, then, has the tendency of allowing large tracts of bottom to remain barren, thus adding fuel to the controversy between the public and private fisherman.

Shellfisheries and Scientists

Until recently, no analogue of U.S. land grant colleges and extension workers has supported and aided the public and private shellfisheries of the eastern United States. Thus, no entity existed whose mission was to develop shellfisheries and to ensure that public funds spent for shellfishery aid and development were effectively used. A mix of divergent attitudes among the 1) drafters of laws, 2) fishermen and local people, and 3) scientists has existed in shellfisheries. The people who wrote the laws which govern the commercial gathering

of shellfish on public beds were primarily concerned with allowing catches to be sufficiently large that fishermen could earn a living, while also conserving shellfish resources. The fishermen and local people are also for conservation, but they want shellfish abundance to be increased, especially during periods of scarcity.

In contrast, many shellfish scientists are interested in conducting research only to obtain knowledge; their concerns about applying the results of that research to economic and social problems in shellfisheries are incidental. Moreover, any studies which they make of factors limiting shellfish production are intermittent, not continuous. Their audience is comprised largely of other scientists. They present their findings at scientific meetings and in journals and they do not interact with fishermen in the way that many agricultural scientists do with farmers. Most papers are not useful in shellfish management.

Scientists have limited knowledge about: 1) How environmental factors govern shellfish abundance, 2) details of how the industry functions and operation of commercial gear, and 3) economics in the fishery. Scientific studies concerning the factors that limit shellfish abundance in beds and development of methods to increase abundance have been largely neglected. Occasionally, communities have asked scientists for advice about management of shellfish resources, especially when abundance, incomes and employment in shellfisheries are low. The usual advice the scientists give is that fewer shellfish should be taken from the beds by fishermen, to allow the beds to become repopulated with legal size shellfish and also to increase the size of the spawning stock. But, as mentioned, that advice is the opposite of what a community wants, because it translates into even lower employment and wealth. Reducing fishing effort is not a good answer to improving shellfisheries.

In shellfishing communities, a common complaint about research is that of irrelevance, i.e., shellfish scientists working on problems that have little to do with the immediate problems of low shellfish production. Local people expect a scientist to "cure" their economic problems in the way that local medical doctors "cure" their health problems. The most important aspect of a fisherman's life is his and his family's health. The local medical doctors are expected to take care of illnesses and they do if they can.

The second most important aspect is the economics of his working life, which is dependent upon shellfish abundance and the market. A shellfishing community anticipates that a scientist will "cure" its economic problems by making shellfish more abundant and handling related production problems. Scientists are not trained to do that, however, and often are so aloof from the fishery and community that they are not cognizant of local needs and desires. When a scientist has failed to increase abundance after a few years of making scientific studies of the local shellfish, the community believes that he has failed in his assignment and "hasn't done anything."

Edwards (1981) described the situation as follows: "Every scientist wishes peer respect and each wishes to survive in his chosen field or work. For the 'strict-sense' or 'hard-core' research scientist, the goal is to move the frontier of science ahead. Introducing this level of scientific interaction into the process of making social judgment frequently only seems to decrease the probability of arriving at a reasonable decision for that time and place. It generally frustrates the nonscientist and enhances the impression that scientists are arrogant and not really responsive to the needs of society. . ."

Note: Nevertheless, a shellfish production specialist can profit considerably from consulting with shellfish scientists and their literature when he seeks answers to biological and ecological questions.

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Knauss Confirmed As Under Secretary of Commerce for Oceans and Atmosphere

The U.S. Senate on Thursday, 3 August 1989, confirmed John A. Knauss, noted oceanographer and educator, as Under Secretary of Commerce for Oceans and Atmosphere. Nominated on 20 July by President George Bush, Knauss succeeds William E. Evans. As Under Secretary, Knauss will be the sixth Administrator of the National Oceanic and Atmospheric Administration (NOAA), the nation's civil air-sea agency and, with 11,500 employees, the largest organization in the Commerce Department.

NOAA includes the National Weather Service, National Ocean Service, National Marine Fisheries Service, National Envionmental Satellite, Data, and Information Service; and the Office of Oceanic and Atmospheric Research.

Since 1962, Knauss has been a professor of oceanography in the Graduate School of Oceanography at the University of Rhode Island. He also served as dean of the URI Graduate School of Oceanography from 1962 to 1987, and as the university's provost for marine affairs from 1969 to 1982.

Knauss has been a member of two presidential commissions on marine affairs: The Commission on Marine Science, Resources, and Engineering (the Stratton Commission) in 1967 to 1968 and the National Advisory Committee on Oceans and Atmosphere (NACOA), 1978-85. He served as chairman of NACOA from 1981 to 1985. He has been president of the Association of Sea Grant Program Institutions, chairman of the Ocean Science Committee of the National Academy of Sciences/National Research Council, and chairman of the Marine Division of the National Association of State Universitates and Land-Grant Colleges.

Knauss has served as president of the oceanographic section American Geophysical Union, vice president of the Marine Technology Society, vice chairman of the American Association for the Advancement of Science's Atmospheric and hydrospheric sciences section, and as council member of the American Meteorological Society. He was a cofounder of the Law of the Sea Institute and served on its governing board from 1965 to 1976 and from 1981 to 1987. He has been elected a fellow of the AAAS, the AGU, and the MTS.

Knauss has served on a number of committees of the National Research Council, including the ocean policy committee and the earth science division, and on advisory committees to several Federal agencies including the Atomic Energy Commission, Coast and Geodetic Survey, U.S. Navy, National Science Foundation, and the State Department. He also served as chairman of the executive committee of the Joint Oceanographic Institutions Deep-Earth Sampling, and is currently a member of the executive committee of the Council for Ocean Law. He received the National Sea Grant Award in 1974. He was elected to the Rhode Island Heritage Hall of Fame in 1982 and received the Rhode Island Science and Technology Award in 1986. Knauss was graduated from Massachusetts Institute of Technology (B.S., 1946), the University of Michigan (M.S., 1949), and the University of California, Scripps Institution of Oceanography (Ph.D., 1959).

Federal 5-year Ocean Pollution Plan Told

A guide to Federal priorities in ocean pollution research programs over the next 5 years was released by the National Oceanic and Atmospheric Administration (NOAA) earlier in 1989. The Commerce Department agency report, "Federal Plan for Ocean Pollution, Research, Development, and Monitoring, Fiscal Years 1988-1992," covers marine pollution programs in the nation's coastal, estuarine, offshore, and Great Lakes areas.

The plan establishes six goals for the National Marine Pollution Program, which is a composite of all marine pollution research and development programs sponsored by the Federal government. The goals include intensive studies of toxic substances, nutrients, and biological agents entering the marine environment as a result of human activities; the loss or modification of marine habitats; conditions and trends in marine ecosystems; and the implication of marine pollution to human health. The report provides over 40 recommendations to the President and Congress concerning future research or activities required to meet the six goals. Some major conclusions and recommendations of the report are described below.

Human Health

Human health concerns related to marine pollution center around toxic chemical substances and pathogenic microorganisms that are found in living marine resources from natural resources or as a result of human activities. It is difficult to establish with certainty the degree of hazard posed by the presence of chemical contaminants in seafood. Existing Federal and state monitoring programs provide only a limited amount of information on the concentration of contaminants in the major commercial and recreational fish species. To evaluate and manage risks to humans associated with seafood consumption, more systematic monitoring of contaminants in seafood will be needed as well as better information on seafood consumption

patterns and continued research on toxic responses in humans.

Government programs have been largely effective in protecting the public from diseases caused by shellfish-borne bacterial organisms. However, because traditionally used microbial water quality indicators do not predict reliably the occurrence of viral pathogens and certain naturally occurring pathogenic bacteria, improved indicators need to be developed.

Monitoring the Status of Marine Ecosystems

It is not possible to predict with confidence the combined effects of all human activities on the marine environment. Therefore, carefully designed long-term monitoring is needed to document status and trends in the overall condition of living and nonliving components of marine ecosystems. Additional research and development is needed to improve our understanding of the relationship between parameters that can be routinely monitored and attributes of the marine ecosystem that are of value to humans.

The report recommends that the National Ocean Pollution Policy Board establish an ad hoc working group of Federal and other scientists and program managers. Such a group would continue to assess the needs of the nation in the marine ecosystems area, determine the appropriate roles of the federal and state levels of government, and propose a systematic strategy for developing a national monitoring capability to meet these needs. The plan recommends that the strategy incorporate existing national and regional programs, make use of historical data, where possible establish guidelines for standardizing monitoring techniques, provide for information synthesis and dissemination, and help assure interagency planning and coordination.

Habitat Loss and Modification

The loss and modification of wetland habitats is a major problem threatening the living marine resources of the nation. Habitat inventory maps produced by the National Wetlands Inventory are as much as 10 years out of date. These maps should be updated more frequently to document habitat loss, especially in areas where rates of change are high.

Scientists and resource managers do not have an adequate understanding of estuarine processes and their importance to habitat functions. Because of this gap, we cannot accurately determine the effects that human activities will have on habitat quantity and quality, the significance of these effects to living marine resources, and the effectiveness of mitigation efforts in actually replacing the functional values of lost habitat.

In addition to several specific research and development studies, the report recommends that the board establish an ad hoc habitat working group. Such a group would address priority program deficiencies related to the loss or modification of habitats, such as those listed above.

The report "National Marine Pollution Program—Federal Plan for Ocean Pollution Research, Development, and Monitoring: Fiscal Years 1988-1992," was prepared by NOAA's National Ocean Pollution Program Office in cooperation with the National Ocean Pollution Policy Board, the interagency group responsible for coordinating all federal pollution research and monitoring programs. Technical support was provided by Technical Resources, Incorporated (TRI) of Rockville, Md. Copies of the report are available from NOAA's National Ocean Pollution Program Office, Room 610, Rockwall Building, 11400 Rockville Pike, Rockville, MD 20852.

U.S. Atlantic Salmon Exploited at Sea

A mathematical model of U.S. Atlantic salmon stocks suggests that as many as 70 percent of adult U.S. salmon may be captured sometime in their life by the interception fisheries in Greenland and Canada. These interceptions occur as the fish move between their at-sea feeding grounds and their homewater spawning streams. The mode, based on U.S. tag-return data, assumes two possible migration routes for the fish between the fishing areas and homewaters.

Results of the model were presented by NMFS Northeast Fisheries Center scientists at a March 1989 meeting in Copenhagen, Denmark, of the International Council for the Exploration of the Sea's North Atlantic Salmon Working Group. Also presented at the meeting was a Center paper on the use of otolith (ear stone) image analysis to determine a salmon's continent of origin. These image analysis techniques are almost as accurate and certainly more cost effective than the biochemical analysis methods currently in use.

NOAA Studies of Alaska Fish Survival Continue

National Oceanic and Atmospheric Administration (NOAA) marine scientists launched another season of research cruises earlier in 1989 in the vicinity of Alaska's Shelikof Strait in an effort to understand the natural forces which influence the abundance of fisheries species there. For the past 3 years, the NOAA researchers have been studying how winds, currents, natural predators, and other factors affect the survival and growth of walleye pollock, *Theragra chalcogramma*, larvae from the rich Shelikof Strait spawning grounds.

This year the scientists—oceanographers, marine biologists, and others-are narrowing their focus to the larvae's main source of nutrition, the zooplankton in the cold waters of the strait, according to James D. Schumacher of NOAA's Pacific Marine Environmental Laboratory in Seattle. Researchers aboard the NOAA ship *Miller Freeman*, working under the direction of Schumacher and Arthur W. Kendall of the Commerce Department agency's NMFS Northwest and Alaska Fisheries Center, Seattle, Wash., will compare concentrations of zooplankton and larvae in waters under the influence of the Alaska coastal current, and waters closer to shore not affected by the current.

For the first time, through cooperation with Texas A&M University, the investigators will have almost immediate access to satellite imagery of Shelikof Strait, allowing them to locate accurate-

ly the position of the Alaska coastal current. This will aid in determining locations at which to collect larvae and zooplankton samples, as well as samples of predators that prey on the larvae. "Through examination of the biological, chemical, and physical forces we hope to determine the rates of mortality for the larvae in these two different types of waters," Schumacher said.

A long-range goal of the Fisheries Oceanography Coordinated Investigations (FOCI) program is to provide policymakers with information upon which they can base decisions on the allowable catch of a fishery species by commercial fishing fleets. The first of four FOCI cruises focussed on eggs and predators. Two more cruises were concerned with sampling and physical oceanography, and the final cruise set for late May 1989, will study late-stage larvae and their environment. Other scientists involved in the investigations come from NOAA's Atlantic Oceanographic and Meteorological Laboratory in Miami, Fla., and the Bigelow Laboratory in Boothbay Harbor, Me.

Overfishing in Antarctic Halted

Overfishing of Atlantic fish stocks, viewed only 2 years ago as a serious threat to the area's marine ecosystem, has been halted, according to the National Oceanic and Atmospheric Administration (NOAA). A new management regime, enacted by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), calls for limiting harvests, reducing the mesh size of nets, closing areas inhabited by juvenile fish, and eliminating fishing during spawning period. CCAMLR is a treaty-based organization with 21 member nations, including the United States, Soviet Union, China, Poland, Chile and Japan.

The area's krill population is estimated to be about 500,000 metric tons, about what it has been in previous years. The Commission recommended improving methods for estimating krill abundance and reporting krill catches in heavily fished areas. The Commission's decision was grounded in large part on fish surveys carried out by NOAA scientists during the Antarctic summer (December 1987-March 1988).

NOAA scientists examined fish populations around the islands of South Georgia and krill populations around the Antarctic Peninsula, the principal fishing areas for these stocks. Krill, a small shrimp-like creature, is the keystone prey organism in the Antarctic ecosystem. It is especially important to whales. NOAA chartered the Polish fisheries research vessel *Professor Siedlecki* and worked with Polish scientists during the surveys. Although NOAA says harvesting krill poses no risk to that resource, it cautions that fish populations continue to fall. For example, NOAA scientists said, the Antarctic fish harvest fell from 400,000 metric tons in 1970 to 74,000 metric tons in 1988. The chief Antarctic fishing nations are the Soviet Union, East Germany, and Poland.

Cordell Bank Named A Marine Sanctuary

The marine waters surrounding Cordell Bank, off Point Reyes, Calif., were designated as a national marine sanctuary, placing the area under the protection and management of the National Oceanic and Atmospheric Administration (NOAA), by that agency in May 1989. The sanctuary encompasses a 397.05 n.mi.^{2} area of waters 20 n.mi. west of Point Reyes, 50 n.mi. west-northwest of San Francisco, and just north of the existing Gulf of the Farallones National Marine Sanctuary. The regulations implementing the designation include a prohibition on oil and gas activities in the core of the sanctuary, an area of about 18.14 n.mi.^{2}.

Simultaneously with publishing these regulations, NOAA proposed a regulatory expansion of the ban on oil and gas activities to the rest of the sanctuary. NOAA is preparing a supplemental environmental impact statement on the proposal and will be soliciting public comments on the matter.

Title III of the Marine Protection, Research, and Sanctuaries Act of 1972, as amended, authorizes the Secretry of Commerce to designate National Marine Sanctuaries of special national significance for the purpose of protecting and conserving special, discrete, highly productive marine areas and ensuring the continued availability of the ecological, research, educational, aesthetic, historic, and recreational resources located within the sanctuary. The designation and implementing of the area's regulations automatically take effect after the close of a review period of 45 days of continuous session of Congress unless the designation or any of its terms is disapproved by Congress through enactment of a joint resolution.

Cordell Bank, which lies on an underwater plateau 300-400 feet below the surface, consists of a series of steep-sided ridges and narrow pinnacles rising from the edge of the continental shelf to within about 115 feet of the surface. Abundant nutrients combine with high light penetration and a wide range of water depths to produce a unique biological community of subtidal and oceanic algae, invertebrates, fish, marine mammals, and seabirds. The designation brings to eight the national marine sanctuaries protected and managed by NOAA. The others are Gulf of the Farallones Islands and the Channel Islands off California, Fagatele Bay in American Samoa, Looe Key and Key Largo off Florida, Gray's Reef off South Carolina, and the site of the wreck of the Civil War ironclad Monitor, off North Carolina.

Tiny Predator Threatens Great Lakes' Food Web

A half-inch-sized predatory creature from Europe threatens to disrupt the food web in all of the Great Lakes, a National Oceanic and Atmospheric Administration (NOAA) scientist has confirmed. Henry A. Vanderploeg of NOAA's Great Lakes Environmental Research Laboratory in Ann Arbor, Mich., has demonstrated the voraciousness with which *Bythotrephes*—a European zooplankter—is consuming another type of zooplankter commonly

known as the water flea. The latter are a dietary mainstay for juvenile alewives, bloaters, and perch, which in turn are the forage of large predatory fishes such as salmon and trout.

Whether the predators will affect fishing in the Great Lakes, now largely restricted to recreation, depends upon the water depth at which the various species of fish normally feed, as well as food web relations not yet understood, Vanderploeg noted. *Bythotrephes* tend to concentrate in the upper 65 feet of the water column. *Bythotrephes* first were reported in Lake Huron in 1984, were found in Lakes Erie and Ontario in 1986, and now have invaded all of the Lakes, Vanderploeg said. It is speculated the predators were transported from Europe in water ballast aboard empty grain freighters from the Soviet Union, and dumped into one or more of the Lakes upon arrival in the United States.

Until now, no reliable data has been available on the extent with which the predators could affect the food web. Vanderploeg used sets of paired traps to capture Great Lakes water with similar concentrations of water fleas and other zooplankters from several sites in Lake Huron. He then introduced a number of *Bythotrephes* into one of the traps in each pair. After 24 hours during which the predators fed on the zooplankton in the trap, the NOAA scientist compared the concentrations. "The technique revealed very high feeding rates for *Bythotrephes* feeding on natural prey assemblages," he said. "These experiments confirm the concern that *Bythotrephes* could have a significant effect on the water fleas, the preferred prey of many forage fishes. It appears that all small zooplankton are vulnerable."

Awards Recognize Top NOAA Employees

NOAA Administrator's Awards and Commerce Bronze Medals were presented to outstanding employees of the National Oceanic and Atmospheric Administration at a luncheon at Ft. Myer, Va., on 23 June 1989.

NOAA Administrator's Awards went to: Eric A. Anderson, National Weather Service, for major scientific and managerial contributions in developing and implementing a new generation River Forecast System; Richard A. Severton, National Marine Fisheries Service, for outstanding leadership in planning and directing multi-agency operations involving fish and and wildlife enforcement; and Marilee Bright, Office of Legislative Affairs, for exceptional skill in controlling and desseminating information allowing quick response to Congressional testimony. Also honored with the Award were: Arva Jackson, Esther Bey, Ellen Overton, and Karen Swanson-Woolf, Office of Legislative Affairs, for development and implementation of the first NOAA Product Information Catalog and retrieval system; Maureen Z. Klink, Western Administrative Support Center, for the development and highly successful implementation of On-Line Payment and Collections (OPEC) procedures; John E. Oliver, Office of the Comptroller, for outstanding achievement in designing the NOAA Coastal Ocean Program as a major agency-wide management initiative; Carmella Davis Watkins (EEO Category Award) National Environmental Satellite, Data, and Information Service, for outstanding leadership of, and commitment to, both NESDIS and NOAA EEO activities; Thomas R. Karl, National Environmental Satellite, Data, and Information Service, for significant leadership and skill leading to NOAA's ability to document, detect, and understand climate change.

Others earning the Administrator's Award were Daniel J. Basta, National Ocean Service, for exemplary leadership of NOAA's Strategic Assessment Program; Robert E. Cheney, National Ocean Service, for outstanding achievement in using GEOSAT satellite altimeter data to obtain a new and revolutionary view of the 1986-87 El Niño; Stephen B. Fels, Office of Oceanic and Atmospheric Research, for pioneering research in atmospheric radiative transfer and its application to weather prediction and climate modeling; Bruce B. Hicks, Office of Oceanic and Atmospheric Research, for outstanding research in dry deposition monitoring in support of the U.S. national acid rain program; Donald Scavia, Office of Oceanic and Atmospheric Research, for outstanding achievement in designing the NOAA Coastal Ocean Program as a major agency-wide management initiative; and Ronald J. Morris, NMFS, Federick H. Beaudry, NMFS, Gary K, Davis, NESDIS, Gary L. Hufford, NWS, Lt. Cdr. Terry D. Jackson, OAR, Glenn Rutledge, NOS, and R.Adm. Sigmund R. Petersen, NOS, for outstanding efforts and accomplishments in freeing California gray whales trapped in ice near Barrow, Alaska.

Department of Commerce Bronze Medals were awarded to: Basil R. Littin, Office of Public Affairs, for outstanding cooperation with the media regarding NOAA satellite operations; Barbara Sue Kreutzer, Mountain Administrative Support Center, for unusual drive and creative ability in leading the MASC's Personal Property and Supply Branch over the past two years; Frederic M. Serchuk, National Marine Fisheries Service, for excellence in fishery resource assessments in the northeastern U.S.A.; Elizabeth F. Edwards and Pierre M. Kleiber, National Marine Fisheries Service, for designing, programming and developing a computer model capable of evaluating a wide variety of fishery assessment techniques; and Roderick A. Scofield, National Environmental Satellite, Data, and Information Service, for outstanding research and leadership in the application of NOAA's satellite data to the improvement of heavy precipitation and flash flood forecasts.

Other Commerce Department Bronze Medalists included Stephen R. Doty, Richard R. Heim, Thomas Reek, and Roger L. Winchell, National Environmental Satellite, Data, and Information Service, for the implementation of the National Climatic Data Center's Drought

Central and its ability to meet the demand for historical drought information; the Office of Satellite Operations (Organizational Award), National Environmental Satellite, Data, and Information Service, for innovation, dedication, and tenacity in prolonging the life of GOES-6; Robert W. Collins, National Weather Service, for extremely valuable contributions made to the Great Lakes marine community; Kenneth B. Mielke, National Weather Service, in recognition of leadership and creative contributions to National Weather Service operations; Andrew D. Stern, National Weather Service, for the development of forecast techniques which have led to increased understanding and use of lightning information in weather warnings; and Leon Minton, National Weather Service, for unusual initiative and creative development of a satellite imagery display capability for observing weather systems.

U.S., Soviet Scientists Investigate North Pacific Sea Lions

In a first-ever venture, Soviet and American scientists were set to carry out a joint survey off Alaska and Siberia during summer 1989 looking for causes for the 50 percent decline in the Northern Pacific sea lion population over the past 15 years. The 7-week investigation, to include areas that have not been examined in almost a century, is part of a U.S.-U.S.S.R. environmental protection agreement and will be headed for the U.S. by researchers from the National Oceanic and Atmospheric Administration (NOAA).

"American biologists have dreamed of a project like this for years," said Richard Merrick, NOAA's project scientist, "because it's in an area that has been inaccessible to us for many years and because cooperative research may be the best way to study shared environmental problems such as declines in North Pacific sea lions and fur seals."

Researchers from the Commerce Department agency's National Marine Fisheries Service and their Soviet counterparts, working from the Soviet research vessel *Rubezhnoe*, expect to tag upwards of 1,000 sea lion pups to determine their movements and reproductive success. Some adult animals will be tagged with special transmitters that can be tracked by satellite. In addition, the scientists will be looking at the incidence of disease among sea lions, contamination of the sea lions by pollutants, and entangling beach debris on the Kurile Islands off Siberia. NOAA said the research team will also be talking to fishing boat crews in the Kurile Islands area and recording critical environmental data, including the location of bird colonies and sightings of other marine mammals such as sea otters.

New Marine Mammal Law and Commercial Fisheries

A new amendment to the Marine Mammal Protection Act requires some commercial fishermen to obtain an exemption from the National Oceanic and Atmospheric Administration (NOAA) to fish lawfully, according to Joseph W. Angelovic, Acting Director, Southeast Region, National Marine Fisheries Service (NOAA Fisheries). The exemption system went into effect on 21 July 1989.

All commercial fisheries are categorized based on the anticipated frequency of incidental take of marine mammals. Category I fisheries are those fisheries with "frequent" incidental takes; Category II fisheries are those with "occasional" takes; and Category III fisheries are those with a "remote likelihood or no known" incidental takes. Take means to harass, hunt, capture, collect, or kill or attempt to harass, hunt, capture, collect, or kill any marine mammal.

Beginning 21 July 1989 all vessel owners in Category I or Category II fisheries were required to register their vessels with NOAA Fisheries prior to engaging in fishing activities. They will receive a decal and an exemption certificate. The application fee is $30.00 annually. Vessel owners must also compile information and file a report about marine mammal interactions once a year or at the end of the fishing season. Observer coverage is mandatory for Category I fisheries, if requested by NOAA Fisheries, and voluntary for Category II fisheries. Category III fisheries are only required to report if they kill a marine mammal during fishing activities. In the Southeast Region only the tuna, shark, and swordfish longline fisheries are classified as Category II; all other fisheries in this region are in Category III.

The purpose of the exemption is to establish a 5-year period for studying the effects of interactions between marine mammals and commercial fisheries. During this period, incidental takes of marine mammals by commercial fisheries will be allowed with a few limitations, and information will be collected that can be used in devising a new long-term solution to the conflict between marine mammals and commercial fisheries. The long-term system is scheduled to be in place by 1 October 1993.

Discoverer Finds Uncharted Sea Mount

Personnel on board the NOAA ship *Discoverer* have located and mapped a previously unknown sea mount in the Pacific Ocean. The undersea mountain is approximately 8 miles long, 2 miles wide, and rises over 10,000 feet from the ocean floor—roughly the size of Mount Baker in northwestern Washington. The new geographic feature, which will be incorporated in future marine charts, is at 1 degree 52 minutes South and 139 degrees 57 minutes West.

Fish-Tag Trophy Winners Named

Winners of the 1988 Captains Trophies were announced by the NMFS SEFC Cooperative Game Fish Tagging Program. The sailfish trophy sponsored by the Sport Fishing Institute was awarded to Captain Frank "Skip" Smith of Burnet, Tex. The white marlin trophy sponsored by the Billfish Foundation was awarded to Captain Dan Timmons of Fort Lauderdale, Fla. The blue marlin trophy sponsored by the National Coalition for Marine Conservation was awarded to Captain Brad Simonds of Islamorada, Fla.

The bluefin tuna trophy sponsored by the International Game Fish Association was awarded to Captain Al Anderson of Narragansett, R.I. The yellowfin tuna trophy sponsored by AFTCO Manufacturing Company was awarded to Captain John Bayliss of Manteo, N.C. The king mackerel trophy sponsored by the Florida League of Anglers was awarded to Captain David Cibluka of Burnett, Tex. Captain Hank Halliger of Pompano Beach, Florida took the award for the commercial captain who tagged and released the most fish (117 billfish and tunas). Ed Scott, project manager of the tagging program, congratulated the winners of the 1988 trophies and everyone who participated in making the 1988 program an outstanding success.

U.S. and Japan Hold Seminar on Rockfish

Scientists from the United States, Japan, and Canada converged in Honolulu, Hawaii, during 26-30 June 1989 to talk about rockfish, the common name for members of the scorpionfish genus *Sebastes*. The rockfish seminar was sponsored by the National Science Foundation and the Japan Society for the Promotion of Science, according to George W. Boehlert, Director of the NMFS Southwest Fisheries Center's Honolulu Laboratory. Boehlert coorganized the seminar, along with Juro Yamada from the University of Hokkaido in Hakodate, Japan.

The 24 scientists attending the meeting presented papers on the reproduction, physiology, life history, and aquaculture of rockfish. Many of the papers resulted from a 4-year cooperative research program between U.S. and Japanese scientists.

With about 106 species worldwide, rockfish are found in temperate, and Arctic regions. One rockfish species, *S. capensis*, even occurs south of the equator. Rockfish give birth to live young after brooding (that is, incubating their eggs) for about 1 month. This makes their reproduction very interesting to scientists.

Some papers presented at the conference examined the feasibility of raising commercially important rockfish in hatcheries, just as salmon, trout, and other fish species are being raised for later release in the wild. Pilot studies in Japan—where raising young rockfish is much more advanced than in the United States—have raised rockfish to a viable size and then released them in the open ocean. Later, these rockfish may be captured as adults by commercial fishermen. Such hatchery releases may help prevent natural populations of rockfish from becoming depleted, but have not been proven to be effective as yet.

According to Boehlert, the meeting gave scientists an opportunity to compare the research being done by the different countries and to discuss the possibility of conducting cooperative research in the future. One interesting point made at the meeting was that, based on the published literature, the U.S. scientists tend to direct more of their research toward field ecology studies and fisheries research, whereas Japanese scientists were more likely to study reproductive physiology and aquaculture.

The papers presented at the meeting are being reviewed for publication and will be edited by Boehlert and Yamada. The meeting was held at the East-West Center Thomas Jefferson Hall on the University of Hawaii-Manoa campus.

Predators of Juvenile Hard Clams Identified

Juvenile mud crabs (family Xanthidae) and adults of tow species of amphipods (small shrimp-like animals) appear to be major predators of juvenile northern quahogs (hard clams) during the quahogs' first week of settling. That's a finding from the NMFS Northeast Fisheries Center's study of causes of natural mortality in economically important species, particularly during the highly vulnerable early life stages.

The predatory potential of the juvenile crabs and adult amphipods upon the juvenile quahogs is exemplified by the situation in Barnegat Bay, N.J. (prime habitat for northern quahogs). During October 1987 in the bay, an average of 17 juvenile mud crabs was found for every square meter of the bottom. In the lab, these crabs each consumed at least 100 juvenile quahogs a day.

Drift Gill Nets Banned for Some S.E. Mackerels

Drift gill nets may not be used in the exclusive economic zone (EEZ) to fish for king mackerel of the Gulf migratory group or Spanish mackerel of the Gulf and Atlantic migratory groups, Joseph W. Angelovic, Acting Regional Director, Southeast Region, National Marine Fisheries Service, has announced. These drift net prohibitions became effective 14 August 1989, and are contained in the final rule implementing the partially approved Amendment 3 to the Fishery Management Plan for Coastal Migratory Pelagic Resources (Mackerels) of the Gulf of Mexico and South Atlantic (FMP). Amendment 3 was prepared by the South Atlantic and Gulf of Mexico Fishery Management Councils. The prohibitions are intended to protect and rebuild the three overfished mackerel groups and to forestall early season closures that negatively impact users of traditional gears. The Councils will reconsider use of drift gill nets when stock conditons improve.

Under the new regulations, a vessel in the EEZ or having fished in the EEZ with a drift gill net aboard may not possess Spanish mackerel. Similar restrictions apply to the possession of Gulf group king mackerel within its seasonal boundaries as shown on the other side. These prohibitions do not apply to the Atlantic migratory group of king mackerel or other coastal migratory pelagic fishes (cero, cobia, dolphin, little tunny, and in the Gulf of Mexico, bluefish) managed under the FMP.

A drift gill net is defined as a gill net having a float line that is more than 1,000 yards in length. It is also defined as a gill net having a float line that is 1,000 yards or less in length, other than a run-around gill net, that, when used, drifts in the water, that is, is not anchored at both ends, whether or not it is attached to a vessel. A run-around gill net is defined as a gill net with a float line 1,000 yards or less in length that,

when used, encloses an area of water. To report violations of these drift gill net prohibitions or other provisions of the FMP contact NOAA Fisheries Enforcement at 813/893-3145 or the nearest U.S. Coast Guard Station.

Heat Emitted to Arctic by Open Water in Ice Pack

Wide open-water areas in the Arctic sea ice are sending heat and moisture high enough into the atmosphere to affect both heat and radiation there, Russell E. Schnell, a scientist with the National Oceanic and Atmospheric Administration (NOAA), reports. Ice crystals carried into the troposphere, the area extending 7-10 miles out from earth, may reflect radiation back into the lower atmosphere and form a thermal blanket retaining additional heat over the Arctic, Schnell says. The result is that the Arctic's role as a global heat sink may require reevaluation, and current climate models may require refinement, he adds.

In the British scientific journal *Nature*, Schnell reports that airborne infrared lidar has detected plumes of ice crystals rising from leads (open-water areas) as much as 6 miles wide and other open areas in the ice called polynyas. They transport heat and moisture as high as 2½ miles into the troposphere, well above the atmospheric boundary layer.

Because earlier investigations had suggested that a temperature inversion dominating the lower Arctic troposphere in winter trapped heat and moisture in the boundary layer, it has been assumed that open-water areas in the ice had little, if any, effect on Arctic heat and radiation. This assumption is reflected in computer programs used to simulate global atmospheric warming.

"The view that turbulence from leads and polynyas affect only the boundary layer needs modifying," Schnell said. "If heat and moisture from leads can regularly reach the mid-troposphere, the role of the Arctic as a global heat sink may need reevaluating, and climate models will require more realistic values of surface-atmospheric fluxes."

Schnell, an atmospheric scientist with the Cooperative Institute for Research in Environmental Sciences, a joint NOAA-University of Colorado research organization in Boulder, Colo., has led several NOAA-sponsored expeditions to the Arctic, studying the Arctic haze and other environmental phenomena. He is based at NOAA's Environmental Research Laboratories in Boulder. The lead plumes were first seen in cloud microphysical data obtained by lidar during a 1984 Arctic flight north of Ellesmere Island toward the North Pole, and again in 1986 during flights near Thule, Greenland. Most leads in the Arctic sea ice are too small to produce sizeable plumes, Schnell said, but those that are large enough have a major role in turbulent heat transfer to the higher Arctic atmosphere. Further research, Schnell said, will focus on developing a climatology of lead occurrence and of plume frequency and distribution in the Arctic from lidar profiles and satellite data. The study was supported by the Office of Naval Research, the National Science Foundation, and NASA.

NMFS-Tagged Shark Sets Time-at-liberty Record

A recent recapture of a tagged sandbar shark after more than 24 years at liberty has set a new time-at-libery record for the NMFS Cooperative Shark Tagging Program and for any shark in the Atlantic Ocean. The male sandbar was tagged during summer 1965 in Delaware Bay by an NMFS scientist, and then recaptured during summer 1989 in the Gulf of Mexico by a commercial longliner.

When the fish was tagged, it was 52 inches long; when it was recaptured, it was 72 inches long. The average growth rate was less than 1 inch per year. Other tag returns have shown this species to be slow growing. The NMFS Cooperative Shark Tagging Program has established that many species of sharks have slow growth, slow maturation, and low reproductive potential (i.e., they're live bearers), all indicating that they could be easily overfished and should be carefully managed.

Korean Fisheries and the Korea-U.S. Fish Trade

Introduction

The Republic of Korea (ROK), the world's fifth largest importer of U.S. fishery products in 1988, purchased over 16,000 metric tons (t), valued at nearly $46 million. The ROK, however, accounted for only about 2 percent of the total U.S. fishery products sold worldwide. The U.S. share of the ROK fisheries import market has fluctuated widely over the last decade. It decreased from nearly 80 percent in 1980 to only 18 percent in 1984, but rebounded to 30 percent in 1986. Conversely, the United States purchased about 61,000 t of fishery products, valued at $243 million, from the ROK in 1988. The United States has historically been the ROK's second largest market for fishery commodities, purchasing an average 11 percent of Korea's total fishery exports annually, from 1980 to 1986.

Table 1.—Republic of Korea fisheries catch, 1980-87. (Source: FAO data.)

Year	Quantity (t)	Year	Quantity (t)
1980	2,091,134	1984	2,477,080
1981	2,365,990	1985	2,650,026
1982	2,280,821	1986	3,103,468
1983	2,400,387	1987	2,876,367

Table 2.—The Korean fishery trade with the United States: imports and exports in current and real dollar values, 1980-88[1].

Year	Inflation rate	Imports (US$1,000)		Exports (US$1,000)	
		Current	Real[2]	Current	Real[2]
1980	13.5	27,679	27,679	69,793	69,793
1981	10.3	26,853	24,356	91,659	83,135
1982	6.2	21,639	18,478	89,218	76,192
1983	3.2	22,529	18,631	99,890	82,609
1984	4.3	12,288	9,744	101,451	80,451
1985	3.6	25,314	19,390	109,880	84,168
1986	1.9	32,728	24,579	165,196	124,062
1987	3.6	42,732	30,981	282,510	204,820
1988	N/A[3]	45,898	N/A	243,146	N/A

[1]Sources: U.S. Department of Commerce, Bureau of the Census, 1980-1988; Consumer Price Index, U.S. Bureau of Labor Statistics.
[2]1980 constant dollars.
[3]N/A = Not available.

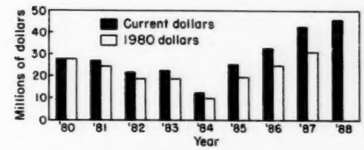

Figure 1.—Korean fishery imports from the United States by value, 1980-88. Source: U.S. Bureau of the Census (Consumer Price Index inflation rate).

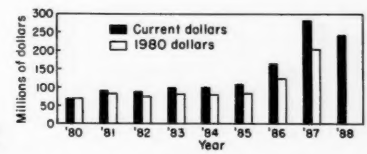

Figure 2.—Korean fishery exports to the United States by value, 1980-88. Source: U.S. Bureau of the Census (Consumer Price Index inflation rate).

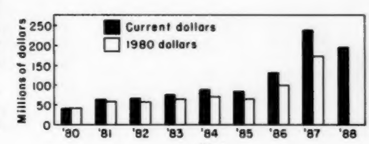

Figure 3.—U.S. fisheries trade deficit with the Republic of Korea, 1980-88. Source: U.S. Bureau of the Census.

Background

The ROK has, in recent years, become one of the world's leading traders of fishery products. The country's tight import regulations have generally discouraged the importation of fish for domestic consumption, and have instead emphasized importing for the purpose of processing and re-exporting to earn foreign currency. Most of Korea's fishery imports from the United States were earmarked for re-export to Japan where they competed with U.S. fishery exports. Although the ROK still imports and re-exports a large quantity of fishery products, a booming domestic economy (with real GNP growth of about 10 percent in 1988) and a higher standard of living has greatly affected this pattern. Per capita disposable income in the ROK quadrupled between 1975 and 1986, from under $500 per year to $2,100 per year. This has resulted in a growing population and an increasing consumer demand for fish and processed fishery products. The ROK's fishing industry has not been able to keep pace with this demand; as a result, South Koreans have had to increase fishery imports to satisfy domestic consumption.

The Korean fisheries catch has averaged about 2.5 million t per year since 1980 (Table 1). In 1986, the ROK had a record catch of 3.1 million t, but the 1987 catch slipped back to 2.8 million tons[1], primarily due to difficulties in obtaining access to distant-water fishing grounds. The Korean Government is hoping that the expansion of fishing grounds (particularly in the Bering Sea and the South Pacific), promotion of new harvesting and processing technology, replacement of older fishing vessels, renewed emphasis on aquaculture, and strengthening of marine pollution control regulations will boost the fishery catch back over the 3 million t mark.

[1]The ROK's 1988 catch statistics were unavailable.

Despite growing consumer demand in the ROK, the U.S. fisheries trade deficit with South Korea has steadily increased in this decade, both in real and current dollars (Fig. 1-3; Table 2). The trade deficit grew from $42 million in 1980 to nearly $240 million in 1987. Record U.S. fishery exports to the ROK in 1988, however, reduced the deficit to $197 million. From 1986 to 1988, the Korean

Table 3.—Korean fishery imports and exports, all countries compared to the United States, by value, 1980-88[1].

	Imports (US$1,000)		Exports (US$1,000)	
Year	Total[2]	From U.S.[3]	Total[2]	To U.S.[3]
1980	35,070	27,679 (79)	759,524	69,793 (9)
1981	58,010	26,853 (46)	931,686	91,659 (10)
1982	56,372	21,639 (38)	861,171	89,218 (10)
1983	57,167	22,529 (39)	826,839	99,890 (12)
1984	68,044	12,288 (18)	877,518	101,451 (12)
1985	89,977	25,313 (28)	890,815	109,880 (12)
1986	117,079	32,728 (30)	1,273,338	165,196 (13)
1987	N/A[4]	42,732 N/A	N/A	282,510 N/A
1988	N/A	45,898 N/A	N/A	243,146 N/A

[1]Sources: FAO (for total ROK fishery imports, 1980-1986); Ministry of Agriculture and Fisheries, Republic of Korea (for total Korean fishery exports, 1980-1986); U.S. Department of Commerce, Bureau of the Census (for U.S. import and export statistics, 1980-88).
[2]The total imports and exports columns may not be completely compatible, as FAO statistics (total imports) do not include seaweeds, but ROK Ministry of Agriculture and Fisheries statistics (total exports) do.
[3]Joint venture sales are not included. Data in parentheses indicate the percentage of the total.
[4]N/A = Not yet available.

Table 4.—Korean fishery imports from the United States, by commodity and quantity, 1980-88. Source: U.S. Department of Commerce, Bureau of the Census.

	Imports (t)								
Commodity	1980	1981	1982	1983	1984	1985	1986	1987	1988
Edible									
Fish									
Frozen[1]									
Whole[2]	3,886.9	9,173.2	7,043.1	6,364.5	6,276.0	6,946.0	10,223.0	10,630.0	5,271.1
Fillets	21.4	2,011.8	1,556.5	1,257.1	236.5	158.9	799.2	831.0	1,622.0
Canned	3.4	5.6	9.6	5.2	0.1	0.9	14.3	20.5	1.2
Cured	459.5	1.3	745.5		4.4	0.8		2.0	12.4
Roe	1,728.1	986.5	1,680.0	1354.5	657.5	2,801.0	289.8	423.6	2,321.5
Other	26.8	58.4	40.4	59.7	55.5	8.1	10.3	37.1	3,639.5
Subtotal	6,126.1	12,236.8	11,075.1	9,041.0	7,230.0	9,915.7	11,336.6	11,944.2	12,867.7
Shellfish									
Frozen[1]	41.7	66.5	31.4	861.9	731.5	1,075.4	2,897.3	2,852.6	1,961.3
Canned	38.9	9.3		92.0	17.5	5.5	10.1	22.0	42.7
Other		3.5	0.6		2.3	0.7	3.1	5.4	43.3
Subtotal	80.6	79.3	32.0	953.9	751.3	1081.6	2,910.5	2,880.0	2,047.3
Total edible	6,206.7	12,316.1	11,107.1	9,994.9	7981.3	10,979.3	14,247.1	14,824.1	14,915.0
Inedible									
Meal/scrap							96.2	364.7	518.9
Oil	18.2	6.4	9.9	3.8	6.9		0.4	0.2	59.5
Other[3]	606.6	584.0	249.8	261.6	130.1	53.1	328.2	645.4	761.0
Total inedible	624.8	590.4	259.7	265.4	137.0	53.1	424.8	1,010.3	1,339.4
Inedible partial fishery products	N/A[4]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Grand total[5]	6,831.5	12,906.3	11,366.7	10,260.3	8,118.4	11,032.2	14,671.8	15,834.4	16,254.4

[1]May include small quantities of live and fresh product.
[2]May include small quantities of live product.
[3]Marine shells and other industrial fishery products.
[4]N/A = Not available.
[5]Columns may not sum to total because of rounding.

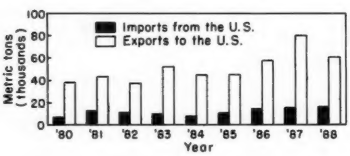

Figure 4.—Korean fishery trade with the United States by quantity (inedible partial fishery products not included), 1980-88. Source: U.S. Bureau of the Census.

won[2] appreciated more than 30 percent against the U.S. dollar, partially accounting for the success of 1988 U.S. fishery exports to Korea. Korea has also taken advantage of the rapid appreciation of the Japanese yen and has boosted fishery exports to Japan, many of which are re-exported imports from the United States.

Korea's Imports From the United States

Overview

Although South Korean imports of U.S. fishery products have fluctuated over the past 9 years, the overall trend is up (Fig. 1, 4; Table 3). The ROK is the fifth largest importer of U.S. seafood products in the world, behind Japan, Canada, the United Kingdom, and France. The United States shipped 16,250 t of fishery products, valued at nearly $46 million, to the ROK in 1988 (Tables 4-7). This represented an increase of nearly 3 percent by quantity and 8 percent by value over U.S. fishery exports to South Korea in 1987 (15,800 t, valued at $43 million). Despite this increase, the ROK purchased only 2 percent, by value, of the total U.S. fishery products exports to all countries in 1988.

Along with the small increase in fishery imports from the United States, the ROK has also greatly increased its joint venture fishery operations in the U.S. Exclusive Economic Zone (EEZ) in recent years. The value of over-the-side sales of Alaskan groundfish (primarily walleye pollock) by U.S. fishermen to Korean processing vessels grew from $6.5 million in 1983 to about $55 million in 1988 (Table 8). This increase was triggered by a drop in the ROK directed fishing allocation in U.S. waters, from 279,000 t in 1983 to 0 in 1988. Although U.S. Customs has not recorded joint venture sales of fish over-the-side to Korean processing vessels as exports in the past[3], the ROK Customs has counted them as imports from the United States. If U.S. Customs had included joint venture sales as exports, however, U.S. fishery exports and joint venture sales to the ROK would have totaled over $100 million in 1988. Foreign fishery joint ventures in U.S. waters will be phased out in the near future because of the growing demand for fishery resources by U.S. fish processors. There is not enough fish to satisfy both U.S. domestic demand and foreign joint venture requests.

[2]The exchange rate was at about 630 won per U.S. dollar.

[3]The U.S. Customs Service will begin counting U.S. Fishery Joint venture sales as exports in 1989.

Korea's Import Policies

The ROK prohibited imports of many fishery products for domestic consumption until 1978. At that time, the Korean Government began to relax import restrictions to prevent an increase in domestic prices caused by expanded consumer demand for fishery products. However, Korea still requires import licenses and imposes tariffs on foreign fishery imports to protect its domestic fishing industry and prevent an over-reliance on foreign fishery imports. Fishery products can be imported duty free when they are processed in Korea and then re-exported.

Import Licensing

A serious barrier in exporting fishery products to the ROK is the Korean government's requirement for import permission (i.e., an import license). Some fishery commodities are approved without question and are said to be on the "automatic approval" list. Despite some progress in liberalizing fishery imports, many fish and shellfish products are still on a restricted list. To import a restricted fishery commodity, special permission must be secured from the Administrator of the National Fisheries Administration on a case-by-case basis.

ROK government officials have rejected U.S. requests that specific fishery commodities be liberalized, stating that licensing restrictions are actually protecting U.S. exporters of these commodities by keeping cheaper imports from the Soviet Union and other countries from competing with U.S. fishery products on the Korean market. They also claim that it has not been politically expedient for the Korean government to completely liberalize fishery imports. South Korea's fishermen present a potent political force and the government has had to show a strong front against outside pressures to liberalize to please this constituency. The restricted commodities most important for U.S. exporters are various Alaska groundfish (walleye pollock, turbot, flounders, yellowfin sole, and halibut). Other items, such as rockfish, sablefish, and herring are among the many commodities on the ROK's automatic import approval list, but these products are mainly re-exported to Japan.

Table 5.—Korean fishery imports from the United States, by commodity and value, 1980-88. Source: U.S. Department of Commerce, Bureau of the Census.

Commodity	Imports (US$1,000) 1980	1981	1982	1983	1984	1985	1986	1987	1988
Edible									
Fish									
Frozen[1]									
Whole[2]	6,061.0	20,188.2	12,714.8	13,023.4	8,199.6	12,144.6	20,341.7	21,956.8	14,622.3
Fillets	56.1	3,454.0	2,590.5	2,610.4	520.9	270.7	1,229.3	1,134.7	3,900.3
Canned	17.2	25.7	63.3	14.0	0.8	5.5	31.5	76.1	20.3
Cured	456.5	9.9	2,111.1		10.9	4.2	0.0	23.2	85.6
Roe	20,292.6	1,905.0	3,458.9	3,653.8	1,009.2	9,833.9	570.6	1,995.3	5,969.5
Other	99.5	172.8	132.5	193.1	179.6	26.1	14.3	114.7	7,083.8
Subtotal	26,982.9	23,879.1	16,396.7	19,494.7	9,921.0	22,285.0	22,187.4	25,300.8	31,681.8
Shellfish									
Frozen[1]	96.4	237.2	183.9	2,225.8	1,911.3	2,798.0	9,620.3	15,632.6	11,750.2
Canned	97.0	58.6		259.2	98.3	25.2	129.9	468.1	199.6
Other		32.5	7.3		13.6	5.5	19.0	44.6	150.6
Subtotal	193.4	328.3	191.2	2,485.0	2,023.2	2,828.7	9,769.2	16,145.3	12,100.4
Total edible	27,176.3	26,084.0	21,262.3	21,979.7	11,944.2	25,113.7	31,956.4	41,446.1	43,782.2
Inedible									
Meal/scrap							23.6	92.9	157.2
Oil	72.8	52.0	30.4	9.8	8.7		2.8	1.7	190.3
Other[3]	401.3	706.1	343.7	518.4	319.9	66.6	431.6	1,009.2	1,667.1
Total inedible	474.1	758.1	374.1	528.2	328.6	66.6	458.0	1,103.7	2,014.6
Inedible partial fishery products	28.5	11.1	2.5	21.4	15.6	133.5	313.8	182.3	101.1
Grand total[4]	27,678.9	26,853.2	21,638.9	22,529.3	12,288.4	25,313.8	32,728.2	42,732.1	45,898.9

[1]May include small quantities of live and fresh product.
[2]May include small quantities of live product.
[3]Marine shells and other industrial fishery products.
[4]Columns may not sum to total because of rounding.

Table 6.—Korean fishery imports from the United States, by species and quantity, 1980-88. Source: U.S. Department of Commerce, Bureau of the Census.

Species	Imports (t) 1980	1981	1982	1983	1984	1985	1986	1987	1988
Edible									
Herring[1]		7,957.3	6,017.4	4,753.5	4,521.0	5,804.5	5,866.0	6,627.5	3,609.1
Salmon[1]	782.1	2,434.2	2,377.1	1,747.6	1,321.3	670.9	4,685.1	2,561.8	2,579.9
Crabs		64.9	2.9	358.1	520.4	1,049.5	2,862.9	2,668.3	1,766.2
Pollock[1]							36.1	553.9	1,005.9
Cod							167.5	246.8	654.2
Eels									248.0
Squid								18.1	224.0
Sablefish							195.1	158.2	
Halibut							37.1	139.4	40.8
Abalone						2.2	6.9	22.0	
Lobster						5.2	9.2	12.4	4.7
Shrimp	1.0	1.4	3.4	5.0	10.7		2.1	3.4	4.7
Scallops						3.0	2.5	1.3	2.8
Mackerel		77.5	34.6						
Sardines				3.4					
Other fish	5,342.9	1,754.9	2,645.5	2,535.7	1,387.8	3,440.3	349.6	1,656.6	4,729.7
Other shellfish	79.6	13.0	25.7	590.7	220.3	3.6	27.2	154.4	44.9
Other edible[2]	1.1	12.8	0.5	0.9					
Total edible	6,206.7	12,315.9	11,106.9	9,994.9	7981.3	10,979.2	14,247.3	14,824.1	14,915.0
Inedible									
Meal/scrap							96.2	364.7	518.9
Oil	18.2	6.4	9.9	3.8	6.9		0.4	0.2	59.5
Other[3]	606.6	584.0	249.8	261.6	130.1	53.1	328.2	645.4	761.0
Total inedible	624.8	590.4	259.7	265.4	137.0	53.1	424.8	1,010.3	1,339.4
Inedible partial fishery products	N/A[4]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Grand total[5]	6,831.5	12,906.3	11,366.7	10,260.3	8,118.4	11,032.2	14,671.8	15,834.4	16,254.4

[1]Including roe.
[2]Includes fish sticks, pastes, balls, etc., of various species.
[3]Marine shells, carrageenin, etc.
[4]N/A = Not available.
[5]Columns may not sum to total because of rounding.

Table 7.—Korean fishery imports from the United States, by species and value, 1980-88. Source: U.S. Department of Commerce, Bureau of the Census.

Species	Imports (US$1,000)								
	1980	1981	1982	1983	1984	1985	1986	1987	1988
Edible									
Crabs	1.0	218.5	57.6	1,095.5	1,351.7	2,723.2	9.437.8	15,037.7	11,608.7
Salmon[1]	1,668.7	9,618.7	4,035.0	4,364.9	1,900.1	1,177.9	7,707.7	6,084.8	9,539.9
Herring[1]		12,727.3	11,015.9	9,794.9	6,169.3	10,623.5	12,908.6	15,411.6	8,181.8
Pollock[1]							19.9	369.8	2,166.0
Cod							506.2	463.7	1,826.9
Eels									662.2
Halibut							115.8	621.3	198.1
Squid								11.4	131.5
Lobsters						39.8	70.7	135.8	80.7
Shrimp	4.8	10.2	38.0	29.3	138.4		10.4	17.0	62.3
Scallops						28.4	31.2	16.5	41.1
Abalone						10.0	117.8	468.	
Sablefish							585.2	179.5	
Sardines				7.3					
Mackerel		104.1	51.6						
Other fish	25,311.3	3,290.7	5,965.4	5,324.0	1,851.7	10,483.6	343.9	2,170.0	9,106.9
Other shellfish	187.6	99.5	95.7	1,360.3	533.0	27.3	101.3	458.9	176.0
Other edible[2]	2.8	14.9	3.2	3.6					
Total edible	27,176.3	26,084.0	21,262.3	21,979.7	11,944.2	25,113.6	31,956.4	41,446.1	43,782.2
Inedible									
Meal/scrap							23.6	92.9	157.2
Oil	72.8	52.0	30.4	9.8	8.7		2.8	1.7	190.3
Other[3]	401.3	706.1	343.7	518.4	319.9	66.6	431.6	1,009.2	1,667.1
Total inedible	474.1	758.1	374.1	528.2	328.6	66.6	458.0	1,103.7	2,014.6
Inedible partial fishery products	28.5	11.1	2.5	21.4	15.6	133.5	313.8	182.3	101.1
Grand total[4]	27,678.9	26,853.2	21,638.9	22,529.3	12,288.4	25,313.8	32,728.2	42,732.1	45,898.0

[1]Including roe.
[2]Includes fish sticks, pastes, balls, etc., of various species.
[3]Marine shells and other industrial products.
[4]Columns may not sum to total because of rounding.

Table 8.—Korean catches and joint venture purchases of Alaska groundfish in the U.S. EEZ, by quantity and value, 1983-1988[1].

Year	Directed catch (t)	Joint-venture purchases	
		Quantity (t)	Value ($10^6)
1983	279,000	57,000	6.5
1984	276,000	98,000	11.4
1985	225,000	177,000	21.5
1986	97,000	378,000	44.8
1987	3,000	452,000	63.0
1988		389,000	55.0

[1]Source: Office of Trade and Industry Services, National Marine Fisheries Service, 1989.

Tariffs

Korean tariffs for U.S. fishery products are 20 percent ad valorem on the c.i.f. (cost, insurance, and freight) price at the time of import declaration. Fishery tariff rates are expected to fall to 15 percent in 1989, the first phase of a planned reduction to 8 percent by 1992.

Import Quotas

Until recently, the ROK imposed import quotas (quantitative restrictions) in combination with tariffs (called "tariff quotas") on certain categories of imported fishery products, in addition to the import licensing requirement. The purpose of these "tariff quotas" was to allow specific quantities of fishery imports for domestic consumption into the country at reduced tariff rates. For example, frozen fish and cuttlefish were subject to a 10 percent tariff rate (considerably lower than the "normal" rate of 20 percent) with import quota ceilings of 15,000 t and 3,800 t, respectively. "Tariff quotas" were trade concessions set up in response to outside pressure for the liberalization of fishery imports. The Korean government no longer imposes "tariff quotas."

Marketing

Korean marketing channels for fish and fishery products (both imported and domestic) can be quite complicated. Coastal landings are usually sold to local wholesalers, shippers, or processors by dealers who handle the fish on a consignment basis at the local wholesale market. The fish are then transported to inland wholesale markets where they are again sold to wholesalers through dealers. The ROK has 12 inland fish wholesale markets and 10 public fish markets operated by fishery cooperatives. The wholesalers supply the fish to retailers who then sell them to the consumers. In all, the fish may change hands six or seven times before ending up on the family table, substantially escalating retail prices.

The Korean government has been trying to expand market channels by increasing the number of local fish markets, as well as bypassing the coastal middlemen. Fishery products are shipped directly from the landing port to inland wholesale marketing centers. The inland markets then supply the fish to direct retail outlets or supermarkets on a consignment basis. As a result, the number of direct retail outlets for fishery products has reportedly increased in recent years.

Fishery Commodities

The ROK imported a record 16,300 t of fishery products, valued at nearly $46 million, from the United States in 1988 (Tables 4, 5). This was a 3 percent increase in quantity and a 7 percent in value over 1987 imports. As in the past, U.S. shipments consisted primarily of frozen whole fish and fish fillets, fish roes, and frozen shellfish (Fig. 5). Together these commodities accounted for 69 percent of the total quantity and 79 percent of the total value of the 1988 imports from the United States.

Frozen Finfish

The largest and most valuable U.S. export commodity is frozen whole fish and fish fillets. The United States shipped a record 11,500 t to the ROK in 1987, valued at over $23 million. Although frozen whole fish and fillets still held the number one spot in 1988, the quantity exported was only about two thirds of the 1987 level and value was

Table 9.—Korean fishery exports to the United States, by commodity and quantity, 1980-88. Source: U.S. Department of Commerce, Bureau of the Census.

Commodity	Exports (t) 1980	1981	1982	1983	1984	1985	1986	1987	1988
Edible									
Fish									
Fresh/frozen									
Whole	11,000.4	14,321.8	5,944.8	12,510.3	6,679.1	1,678.3	3,195.6	1,722.2	1,375.5
Fillets	1,087.0	1,361.8	1,173.9	2,377.9	4,489.0	6,753.6	11,030.0	16,956.8	10,300.5
Blocks	19,205.0	18,568.7	18,681.9	25,913.2	23,094.4	22,420.3	23,022.0	33,846.7	23,497.9
Loins/discs	559.1	964.7	870.7	273.7					
Subtotal	31,851.5	35,217.0	26,671.3	41,075.1	34,262.5	30,852.2	37,247.6	52,525.7	35,173.9
Canned									
In Oil	213.3	351.7	146.5	231.0	224.3	151.3	228.3	259.9	307.3
Not in Oil	152.5	198.4	172.3	317.1	964.0	1,991.7	3,238.1	4,552.1	3,638.4
Subtotal	365.8	550.1	318.8	548.1	1,188.3	2,143.2	3,466.4	4,812.0	3,945.7
Cured	124.9	218.9	240.5	242.7	332.3	631.6	650.5	724.5	913.9
Roe	15.5	19.9	47.6	74.5	76.3	129.6	151.0	149.5	142.8
Surimi, analogs							1,141.8	3,245.7	4,728.2
Other	253.2	38.4	207.4	294.6	340.3	621.1	699.4	920.0	1,085.8
Shellfish									
Fresh/frozen	1,716.8	1,733.8	2,498.9	2,812.7	2,831.8	3,651.3	5,841.5	7,591.2	6,360.4
Canned	3,784.7	5,120.2	7,469.6	6,796.3	5,744.9	6,643.9	8,414.9	9,447.9	7,237.5
Other					12.4	12.4	62.3	149.6	106.0
Subtotal	5,501.5	6,854.0	9,968.5	9,609.0	8,589.1	10,307.6	14,318.7	17,188.7	13,703.9
Total edible	38,112.4	43,096.4	37,454.1	51,844.0	44,788.7	44,685.3	57,675.4	79,566.1	59,694.2
Inedible									
Meal/scrap						240.4	75.3	361.1	708.5
Oil							Negl.[1]	0.1	9.9
Canned pet food				13.3		12.2			74.2
Other industrial	49.7	123.7	78.4	151.6	108.3	82.7	83.9	67.4	134.5
Total inedible	49.7	123.7	78.4	165.1	108.3	335.3	159.3	428.5	927.1
Inedible partial fishery products	N/A[2]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Grand total[3]	38,162.2	43,220.1	37,532.5	52,009.1	44,897.0	45.020.6	57,834.7	79,994.6	60,621.3

[1]Negl. = Negligible.
[2]N/A = Not available.
[3]Columns may not sum to total because of rounding.

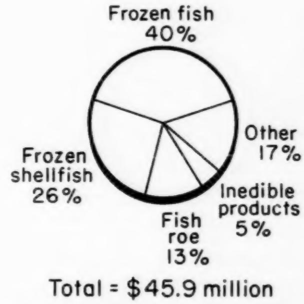

Figure 5.—Major fishery commodities imported by Korea from the United States by value, 1988 (percent of total). Frozen fish is whole and fillets. Source: U.S. Bureau of the Census.

down by over 20 percent (Tables 4, 5). Sales of U.S. frozen fish (and a number of other fishery commodities, such as salmon, crabs, and lobster) to the ROK are largely dependent on Japanese market conditions. With the increased appreciation of the yen and high prices offered by the Japanese in 1988, U.S. fishermen were able to boost sales of frozen fish to Japan by over 50 percent, hence the decrease in frozen fishery exports to the ROK. Japan was the preferred export mmarket for these commodities.

Frozen Shellfish

Frozen shellfish was the second most valuable U.S. fishery commodity exported to the ROK in 1988, accounting for over $12 million (Table 5). Almost 94 percent of this was frozen tanner crab. The record-high year for frozen shellfish exports was 1987, when nearly $16 million worth were shipped to South Korea. As was the case for frozen fish, Japanese markets competed strongly for U.S. crab exports in 1987 and 1988 and are largely responsible for the drop in exports to South Korea.

Fish Roe

Fish roes were the third most valuable U.S. fishery commodity export to the ROK in 1988, valued at almost $6 million. Roe exports increased from only 424 t in 1987 to 2,300 t in 1988 and tripled in value. According to U.S. Customs, herring roe comprised over 70 percent of the total value. These statistics may be misleading, however, as U.S. fishery officials suspect that Customs agents may have mistakenly recorded roe herring (herring from which the South Koreans later remove the eggs) as herring roe. The remainder of U.S. roe exports was reportedly pollock roe. The United States exported a record $20 million worth of fish roes to the Koreans in 1979 and 1980.

Species

The most important species exported by the United States to the ROK in 1988 were, by value, crab, salmon, herring, and walleye pollock (Fig. 6, Table 7).

Crab

The United States exported 1,800 t of frozen crab, valued at almost $12 million in 1988. Alaska tanner or snow crab accounted for nearly 95 percent of the quantity (1,600 t) and value ($11 million) of this total. King crab exports to the ROK in 1988 were small—only 19 t of frozen and 40 tons of canned (valued at $275,000). Overall, 1988 U.S. crab exports decreased in both quantity and value from 1987 exports (see Frozen Shellfish section).

Salmon

U.S. 1988 frozen salmon exports to the ROK amounted to 2,600 t and had a value of $9.5 million. The quantity exported increased only 1 percent, but the

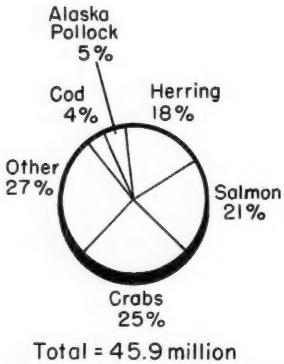

Figure 6.—Major fish species imported by Korea from the United States by value, 1988 (percent of total). Salmon, herring, and pollock data includes roe. Source: U.S. Bureau of the Census. Total = $45.9 million.

Table 10.—Korean fishery exports to the United States, by commodity and value, 1980-88. Source: U.S. Department of Commerce, Bureau of the Census.

	Exports (US$1,000)								
Commodity	1980	1981	1982	1983	1984	1985	1986	1987	1988
Edible									
Fish									
Fresh/frozen									
Whole	13,836.0	19,198.2	7,786.2	12,581.3	7,082.4	2,746.0	3,836.5	3,974.3	4,159.9
Fillets	2,214.1	2,930.3	2,478.1	6,276.8	13,511.0	18,106.0	32,754.9	58,059.5	37,559.4
Blocks	26,627.2	30,817.3	28,011.5	35,585.6	33,136.0	30,568.0	38,100.6	79,209.5	45,596.1
Loins/discs	2,152.9	4,718.8	4,119.4	790.2					
Subtotal	44,830.2	57,664.6	42,395.4	55,233.9	53,729.4	51,421.0	74,692.0	141,243.3	87,355.4
Canned									
In Oil	435.2	897.5	327.4	491.2	521.2	299.5	460.1	627.8	805.0
Not in Oil	360.5	446.7	468.4	844.6	2,014.6	3,911.9	7,426.0	10,714.2	8,998.7
Subtotal	795.7	1,344.2	795.8	1,335.8	2,535.8	4,211.4	7,886.1	11,342.0	9,803.7
Cured	444.6	832.2	866.0	960.7	1,216.2	2,407.3	2,396.7	3,001.3	4,613.6
Roe	91.8	111.8	331.3	510.5	360.5	760.7	990.3	1,088.9	1,185.9
Surimi, analogs							3,476.8	9,692.6	14,750.4
Other	649.7	890.8	699.6	811.9	1,242.4	1,609.5	2,380.8	3,268.1	5,405.9
Shellfish									
Fresh/frozen	4,558.2	4,716.3	11,148.2	12,095.5	11,540.7	13,646.6	27,739.8	46,316.9	43,178.0
Canned	12,628.7	16,809.4	22,907.6	20,587.7	19,133.6	21,301.0	25,268.7	31,521.4	33,974.5
Other					26.2	27.0	125.8	247.6	233.8
Subtotal	17,186.9	21,525.7	34,055.8	32,683.2	30,700.5	34,975.0	53,134.3	78,085.9	77,386.3
Total edible	63,999.0	82,369.2	79,143.9	91,535.9	89,784.8	95,385.0	144,957.0	247,722.2	200,500.9
Inedible									
Meal/scrap						88.4	25.5	89.8	247.2
Oil				0.7			1.6	3.9	350.1
Canned pet food				10.3		9.2			58.1
Other industrial	576.3	866.4	621.0	786.5	894.7	550.7	815.1	660.4	460.5
Total inedible	576.3	866.4	621.0	797.5	894.7	648.3	842.2	754.1	1,115.9
Inedible partial fishery products	5,217.4	8,423.3	9,453.4	7,556.9	10,771.8	13,846.1	19,396.3	34,033.9	41,529.7
Grand total[1]	69,792.7	91,658.9	89,218.3	99,890.2	101,451.2	109,879.9	165,195.6	282,510.2	243,146.4

[1]Columns may not sum to total because of rounding.

value increased by 57 percent over that of 1987. World salmon prices were forced sharply upward in 1988 because of high Japanese demand. Japan's overall salmon catch was down in 1988 (with the exception of the fall chum salmon run in Hokkaido) and Japanese buyers offered top dollar for U.S. salmon. As a result, Korean prices were pushed up, netting the large increase in value of U.S. salmon exports, despite the small quantity increase. Frozen pink salmon ws the major species exported, accounting for 65 percent of the quantity and 55 percent of the value of the total (1,670 t, valued at $5.2 million). Chum salmon was the next most important species ($2.6 million), followed by sockeye ($0.8 million), silver ($0.5 million), and chinook salmon ($0.2 million).

Herring

The United States exported 3,600 t of herring and herring roe, valued at over $8 million, to the ROK in 1988. This was about half of the quantity and value of the U.S. herring exported to Korea in 1987. The Japanese market for herring products was favorable in 1988 and was most likely responsible for diverting more U.S. herring to Japan. Herring roe accounted for nearly 50 percent of the quantity and 53 percent of the value of total 1988 U.S. herring exports to the ROK (see Fish Roe section). South Korean imports of U.S. herring have fluctuated historically, but increased by about $3 million per year from 1984 through 1987.

Pollock

U.S. walleye or Alaska pollock exports to South Korea have increased yearly from only 36 t, valued at $20,000 in 1986, to over 1,000 t, valued at $2.2 million, in 1988. U.S. Customs listed the majority of this total as pollock roe (530 t, valued at $1.6 million). South Koreans have traditionally consumed walleye pollock, which is also harvested off their own coast, but fishermen are now having difficulty supplying it as the United States, the Soviet Union, and North Korea are tightening regulations on foreign fishing in their waters. Consequently, pollock imports are expected to increase rapidly in the near future.

Fishery Exports to the United States

Overview

The value of ROK exports of fishery products to all countries increased by nearly 50 percent from 1985 to 1986 (from $0.9 billion to $1.3 billion—Table 2). Fishery exports in 1986 accounted for about 4 percent of all Korean exports, up from 3.5 percent in 1985. (More recent figures were not available.) The increase in fishery exports was caused by an increased demand for fishery products in Japan and the United States, increasing world export prices, favorable exporting conditions caused by the appreciation of the Japanese yen,

Table 11.—Korean fishery exports to the United States, by species and quantity, 1980-88. Source: U.S. Department of Commerce, Bureau of the Census.

	Exports (t)								
Species	1980	1981	1982	1983	1984	1985	1986	1987	1988
Edible									
Pollock[1]	15,207.7	14,881.4	14,299.8	21,900.1	18,957.2	18,356.9	17,155.3	23,354.3	19,502.4
Oysters	3,675.5	5,352.7	6,875.0	7,043.9	6,202.6	7,652.8	8,882.4	10,069.6	8,183.4
Flat fish		208.6	94.3	848.4	2,225.8	3,563.9	5,493.1	5,876.0	7,039.8
Surimi, analogs							1,141.8	3,245.7	4,728.2
Crabs	158.9	191.5	796.3	750.1	970.5	1,053.7	3,189.5	3,715.2	3,052.5
Cod	3,018.0	3,221.9	2,430.7	3,290.7	3,144.2	2,518.4	4,633.7	8,284.4	2,577.8
Sardines	25.2	33.7	7.4	7.3	256.4	683.7	541.4	1,152.9	960.4
Tuna	11,488.2	15,003.8	6,500.7	12,532.5	6,381.1	1,098.5	3,039.1	823.4	711.6
Clams	564.3	519.3	1,660.6	988.9	628.9	568.6	643.3	1,106.5	672.4
Groundfish	354.7	412.7	866.2	943.0	772.3	1,189.4	1,954.5	3,494.1	610.3
Squid							743.2	916.4	502.3
Mackerel	103.2	67.0	70.4	83.7	231.8	272.3	300.1	417.4	451.6
Shrimp	153.0	196.4	82.7	120.4	118.6	140.2	329.9	522.6	418.1
Salmon[1]					2.6	0.2	50.7	1,011.4	63.0
Yellow perch									51.1
Anchovies							23.7	36.9	43.8
Turbot	42.4	96.7	36.3	16.5		32.2		195.3	38.6
Lobster		0.1		19.1	0.4	7.8	13.2	6.9	18.3
Halibut					26.9			97.9	7.5
Trout				0.2			2.9	74.2	
Whiting	1,352.2	764.7	916.6	309.5	109.4	26.3	36.3	46.5	
Swordfish	0.9		2.0		1.3	3.9		37.5	2.8
Shark fins							0.3	0.3	2.3
Herring[1]					1.9	31.5	52.5	2.0	0.9
Scallops	0.1	0.6	1.8	0.8	0.5	20.2	6.1	4.3	0.7
Ocean perch				61.1	68.1	32.7		32.3	
Abalone		0.1	0.3	3.9			17.8	2.3	
Other fish	771.6	1,343.9	2,088.2	1,957.6	3,714.5	6,155.0	8,401.8	13,701.6	8,577.5
Other shellfish	950.5	601.2	559.3	693.1	667.5	864.3	493.4	840.6	848.5
Other edible	246.0	200.2	165.7	273.2	306.3	413.1	529.4	497.6	628.4
Total edible	38,112.4	43,096.4	37,454.1	51,844.0	44,788.7	44,685.3	57,675.4	79,566.1	59,694.2
Inedible									
Meal/scrap						240.4	75.3	361.1	708.5
Oil				0.2			Negl.[2]	0.1	9.9
Canned pet food				13.3		12.2			74.2
Other industrial	49.7	123.7	78.4	151.6	108.3	82.7	83.9	67.4	134.5
Total inedible	49.7	123.7	78.4	165.1	108.3	335.3	159.3	428.5	927.1
Inedible partial fishery products	N/A[3]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Grand total[4]	38,162.2	43,220.1	37,532.5	52,009.1	44,897.0	45.020.6	57,834.7	79,994.6	60,621.3

[1]Including roe.
[2]Negl. = Negligible.
[3]N/A = Not available.
[4]Columns may not sum to total because of rounding.

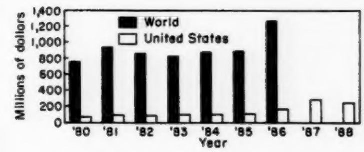

Figure 7.—Korean fishery exports to world markets, compared with the U.S. market, by value, 1980-88. Sources: U.S. Department of Commerce and ROK Statistical Yearbook of Agriculture, Forestry, and Fisheries.

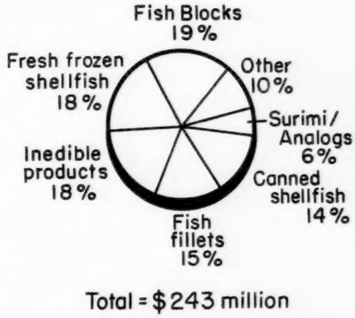

Figure 8.—Major Korean fishery commodities exported to the United States by value, 1988. Source: U.S. Bureau of the Census.

low oil prices, and the development of high-valued processed fishery products by the Koreans. The United States purchased over $165 million worth of Korean fishery products in 1986. The United States has historically been the ROK's second largest market (after Japan), purchasing an average of 11 percent of all Korean fishery exports annually, from 1980 to 1986 (Fig. 7, Table 2). In 1988, the United States purchased a total of nearly 61,000 t of fishery products, valued at $243 million (Fig. 2, 4; Tables 9-12). Because ROK trade statistics were not readily available for years following 1986, the relative significance of fishery exports to the United States was not determined for those years (Fig. 7).

Fishery Commodities

The largest and most valuable Korean fishery commodities exported to the United States are frozen fish (primarily blocks and fillets), frozen and canned shellfish, inedible fishery products, and surimi and surimi analogs (Fig. 8, Tables 9, 10). These commodities accounted for about 88 percent by quantity and 90 percent by value of the total U.S. imports of ROK fishery products in 1988.

Frozen Fish Block and Fillets

Fish blocks were the single most important ROK fishery commodity exported to the United States in 1988; 23,500 t, valued at $45.6 million. This is down by over 10,000 t and $34 million from 1987 fish block exports (33,800 t, valued at $79.2 million). A major factor in this decrease is the reduced access of the South Koreans to raw materials, especially in the U.S. EEZ. In addition, the Koreans are diverting some of the product which was formerly sold in block and fillet form to surimi production, which commands much higher prices. Of the 1988 ROK fish block exports mentioned above, walleye pollock blocks comprised nearly 70 percent of

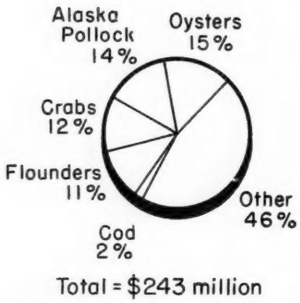

Figure 9.—Major fish species exported by Korea to the United States by value, 1988. Pollock data includes roe. Source: U.S. Bureau of the Census.

the total value—$31.5 million. Cod blocks were second in importance (1,800 t, valued at $5.6 million), followed by flounder blocks (1,600 t, valued at $5.2 million). In the frozen fillet category, flounder fillets topped the list (5,400 t, valued at $21.6 million). Unspecified saltwater fish fillets were second (4,700 t, worth $15 million), followed by hake, haddock, Alaska pollock and cod fillets (a combined 2,500 t, valued at $6.3 million).

Fresh/Frozen and Canned Shellfish

The ROK exported over $77 million worth of these two commodities to the United States in 1988. Fresh/frozen shellfish accounted for about 56 percent of the total ($43.2 million). Fresh/frozen crabs and crabmeat were the most important commodities; 3,000 t were shipped, valued at nearly $28 million. Other important commodities were frozen oysters and squid. Of all ROK canned shellfish commodities shipped to the United States in 1988, canned oysters were by far the most important, comprising over 90 percent of the total. Over 6,600 t of canned oysters and canned smoked oysters, valued at $31 million, were shipped. The ROK also exported small amounts of canned clams, shrimp, and mussels.

Table 12.—Korean fishery exports to the United States, by species and value, 1980-88. Source: U.S. Department of Commerce, Bureau of the Census.

	Exports (US$1,000)								
Species	1980	1981	1982	1983	1984	1985	1986	1987	1988
Edible									
Oysters	11,773.1	16,794.2	21,619.2	21,243.2	20,162.5	23,731.5	26,451.4	33,618.2	35,734.4
Pollock[1]	20,184.7	23,520.0	20,403.7	27,379.6	24,516.6	22,436.7	25,346.9	47,634.0	33,753.0
Crabs	623.5	674.3	6,139.3	5,641.7	5,566.8	5,077.3	20,415.0	32,225.8	28,116.1
Flatfish		490.7	251.3	2,601.8	6,350.7	9,334.6	16,019.7	20,486.7	26,874.9
Surimi, analogs							3,476.8	9,692.6	14,750.4
Cod	5,009.2	6,851.7	4,871.1	6,948.8	6,693,6	5,306.0	11,261.1	29.960.2	8,434.1
Clams	2,231.1	2,027.2	4,678.3	3,068.4	2,320.7	2,146.6	2,023.4	3,614.0	3,651.6
Squid							1,565.8	2,980.0	2,978.7
Tuna	15,900.8	23,337.0	11,095.0	12,737.5	6,174.1	1,083.4	3,316.7	1,198.3	1,832.1
Shrimp	369.4	501.7	203.6	276.7	363.4	331.4	814.3	1,568.2	1,732.8
Groundfish	583.1	796.4	1,553.9	1,715.9	1,387.6	1,892.5	3,455.1	8,812.2	1,595.1
Sardines	32.0	48.4	12.0	23.4	292.7	730.4	608.3	1,318.2	1,246.6
Mackerel	165.6	140.4	136.5	138.9	360.3	400.1	463.9	736.0	1,043.1
Salmon[1]					1.6	3.2	207.2	2,934.3	242.5
Lobster		2.3		209.8	0.8	21.6	20.5	96.1	195.1
Anchovies							45.9	86.3	169.9
Turbot	86.7	189.7	94.8	43.9		110.6		957.1	138.4
Yellow perch									136.5
Halibut					161.0			827.0	68.7
Shark fins							26.5	28.8	51.6
Swordfish	2.8		1.1		2.6	26.1		233.9	19.2
Scallops	0.7	14.4	8.6	12.9	11.1	160.1	15.2	58.3	13.6
Herring[1]				1.5	9.3	49.2	130.9	6.7	5.7
Ocean perch				186.4	216.7	117.3		185.3	
Trout				3.2			8.8	151.5	
Whiting	2,380.8	1,414.4	1,718.5	520.1	199.5	41.2	85.4	102.5	
Abalone	0.9	3.1	12.6	11.4	2.5		43.1	25.9	
Other fish	1,854.6	3,239.7	4,401.9	5,784.8	11,630.8	17,920.9	25,572.7	42,378.2	29,020.8
Other shellfish	2,190.9	1524.3	1,406.7	2,243.6	2,272.7	3,506.6	1,781.6	3,892.2	4,925.0
Other edible	608.9	799.4	535.8	742.3	1,087.1	956.2	1,800.8	1,913.7	3,770.9
Total edible	63,999.0	82,369.2	79,143.9	91,535.9	89,784.6	95,385.6	144,957.0	247,722.2	200,500.8
Inedible									
Meal/scrap						88.4	25.5	89.8	247.2
Oil				0.7			1.6	3.9	350.1
Canned pet food				10.3		9.2			58.1
Other industrial	576.3	866.4	621.0	786.5	894.7	550.7	815.1	660.4	460.5
Total inedible	576.3	866.4	621.0	797.5	894.7	648.3	842.2	754.1	1,115.8
Inedible partial fishery products	5,217.4	8,423.3	9,453.4	7,556.9	10,771.8	13,846.1	19,396.3	34,033.9	41,529.7
Grand total[2]	69,792.7	91,658.9	89,218.3	99,890.2	101,451.2	109,879.9	165,195.6	282,510.2	243,146.4

[1]Includes roe.
[2]Columns may not sum to total because of rounding.

Inedible Fishery Products

Although the value of 1988 ROK edible fishery exports to the United States was down by almost 20 percent from 1987, inedible fishery commodities (both inedible and partial inedible) were up by 22 percent, from $34.8 million to $42.6 million. The most important inedible fishery products in 1988 were jewelry ($17.7 million), leather belts ($9.4 million), and small mirrors ($5.8 million)[4].

[4]There is only a small fishery component to most of the inedible partial fishery products. They are included in this report so that the data corresponds to that reported in the "Fisheries of the United States."

Surimi and Surimi Analogs

The ROK first exported surimi and surimi analog products to the United States in 1986, when it shipped over 1,100 t, valued at $3.5 million. The growth in exports of these commodities has been phenomenal; 1988 shipments to the United States totaled 4,700 t, valued at $14.8 million. Nearly 100 percent of these were analog products—raw surimi exports were neglible.

Species

On a species basis, the ROK's top ten exports to the United States (in order of importance) in 1988 were oysters, walleye pollock, crabs, flatfish, cod, clams,

squid, tuna, shrimp, and various groundfish (Fig. 9, Tables 11, 12). Quantities shipped were down for all of the above, with the exception of flatfish (which increased by nearly 20 percent). Details of the top five exports (by value) follow.

Over 8,000 t of oysters, primarily canned, valued at $35.7 million, were exported to the United States in 1988. The quantity shipped was down 19 percent from 1987, when a record 10,000 t was exported, but the value was up 6 percent.

Walleye pollock was the top species export to the United States by quantity in 1988 (19,500 t), but it took second place by value ($33.8) million). As previously stated, pollock blocks and fillets comprised the bulk of the exports although canned pollock (770 t, valued at $2.3 million) and small amounts of smoked, dried, and salted pollock were also exported (quantity and value not available). U.S. imports of pollock products from the ROK have averaged a little over 18,000 t for the last 9 years. Until 1986, the value of these imports averaged about $23 million. In 1987, the Koreans, exported an all-time record 23,000 t to the United States, worth nearly $48 million.

In 1988, the United States purchased 3,000 t of Korean crabs, valued at $28 million. This was an 18 percent decrease by quantity and a 13 percent decrease by value below record 1987 purchases. U.S. imports of frozen crab and crabmeat have exceeded 3,000 t annually since 1986 (Table 11).

South Korean exports of flatfish (flounders) to the United States have enjoyed steady growth since 1983, when 848 t, valued at $2.6 million, were shipped. By 1988, a much larger amount (7,000 t) of flatfish, worth $26.8 million, was exported—ten times the 1983 exports by quantity and value. The most important commodity forms are frozen fillets, followed by frozen flatfish blocks.

Total 1988 ROK cod exports to the United States were 2,500 t, valued at nearly $8.5 million. Of this total, the most important commodity was frozen cod blocks (totaling 1,800 t, valued at $5.6 million). Cod fillets were next in importance (700 t, valued at $2.4 million) followed by small quantities of frozen whole cod and salted cod. The 1988 ROK cod exports to the United States were down approximately 70 percent by quantity and value over 1987 cod exports (8,200 t, valued at $30 million). This decrease is most likely due to increased sales of cod to the Japanese.

Conclusion

There is little doubt, given South Korea's phenomenal growth rate and increasing affluence, that U.S.-ROK fisheries trade will continue to grow. The rate of growth, however, will continue to be dependent upon the relaxation of import restrictions (import licenses and tariffs) by the Korean Govenment. An additional factor, the influence of the Japanese market on U.S. fishery exports to South Korea, adds a further element of unpredictability. However, as fishery raw materials become more difficult for the Koreans to obtain because of increased control of coastal countries over their own EEZ's, the prospects will continue to improve for U.S. exporters. (Source: IFR-89/52. Prepared by Paul E. Niemeier of the NMFS Foreign Fisheries Analysis Branch, Silver Spring, MD 20910.

The Sea Urchin Market in Japan

The Japanese market for live sea urchin and sea urchin roe from the United States is growing rapidly, but it has not yet been fully developed. Although imported sea urchin has penetrated the Japanese market (U.S. sea urchin exports to Japan have increased from 540 metric tons (t) in 1984 to 1,740 t in 1988: Figure 1), foreign-processed roe remains unpopular, largely because of inconsistencies in quality and supply. The strict quality requirements of the Japanese market will necessitate higher standards on the part of U.S. sea urchin roe processors to guarantee export success.

Consumption

Roe

Sea urchin roe is considered a delicacy in Japan, where it is primarily served raw in sushi. The Japanese name for sea urchin roe is "uni." Most sea urchin roe buyers at Tokyo's Tsukiji Central Wholesale Market purchase for expensive traditional Japanese-style restaurants which demand extremely high quality in both appearance and taste.

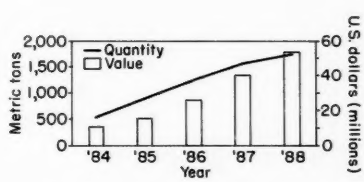

Figure 1.—Japanese sea urchin imports from the United States by quantity and value, 1984-88. Source: Fisheries Agency of Japan.

Although some imported sea urchin roe is currently shipped to Hokkaido and northern Honshu for processing, inferior quality has prevented an increased market share for imported roe. The demand for sea urchin roe is seasonal, with the largest amount being consumed in December. Sea urchin roe is marketed in different product forms: Fresh (nama uni), frozen (reito uni), baked and frozen (yaki uni), steamed (mushi

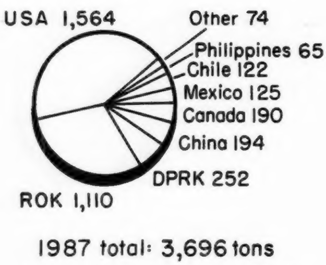

Figure 2.—Japanese sea urchin imports by country of origin and quantity (metric tons), 1987. Source: Fisheries Agency of Japan.

Figure 3.—Japanese sea urchin imports by country of origin and value (millions of dollars), 1987. Source: Fisheries Agency of Japan.

uni), and salted (shio uni). Salting is used primarily for lower-grade roe. Two fermented urchin roe products are also popular in Japan: Neri uni (a blended urchin paste) and tsubi uni (a lumpy paste).

Live Urchin

Virtually no live imported sea urchin is sold at the Tsukiji Market. Buyers of live sea urchin usually prefer the domestic Japanese sea urchin which is limited in supply. Because of the difficulties in shipping and handling live, whole sea urchins, Japanese importers generally prefer to have the roe processed at the place of origin.

Imports

Japan imported 3,700 t of sea urchin in 1987, valued at about $100 million (Fig. 2, 3). Nearly half of the value was supplied by the Republic of Korea (1,110 t valued at $45.3 million), followed by the United States (1,560 t valued at $40.2 million), Canada (190 t valued at $4.2 million), and North Korea (250 t valued at $2.4 million). In 1988, imports from the United States amounted to 1,740 t, with a value of $54 million, becoming the fourth largest U.S. fishery export to Japan by value. Values were not available for 1988 Japanese urchin imports from other countries.

Price

The highest priced sea urching products imported from the United States are the red sea urchin, *Strongylocentrotus franciscanus*, shipped from Los Angeles and from San Francisco. Processed roe from the New England green sea urchin, *S. droedachiensis*, ranks third in price on the Japanese market, and green sea urchin roe harvested in British Columbia, Canada, and Puget Sound, Washington, ranks fourth. Prices of Los Angeles-origin sea urchin roe as of March 1989 were $8.20-$40.98 per tray[1] while British Columbia-origin roe brought only $4.92-$16.39 per tray. The wide price spread reflects the uneven quality of imported sea urchin roe.

The average wholesale price of live sea urchins from the U.S. west coast is around $10.00 per kg from October through April, but falls to around $6.00 per kg during the summer months when fear of food poisoning depresses consumer demand.

Quality Standards

Japanese consumers prefer pale yellow or orange roe over roe with mottled or dark brownish or redish color. Roe color is largely dependent on the diet, sex, and harvest time of the individual sea urchin. In the Sanriku area of Japan, sea urchin roe is steamed and therefore color is not as significant in determining quality and price. Roe from British Columbia is considered to be of inferior quality because the individual roe sacs, which are over 2 inches long, are too large for use in sushi.

Japanese processors look for a roe recovery rate of about 10 percent and require a minimum of 3 metric tons of live sea urchin per day to run their plants efficiently. Inconsistent roe color and recovery percentages and unreliable supply are Japanese processors' chief complaints against U.S.-produced sea urchin products. Because roe recovery percentage and color vary with fishing season and region, U.S. suppliers must pay careful attention to harvest techniques and be willing to adapt them to Japanese taste.

[1]At an exchange rate of $1 = ¥122. One tray contains 260 g of roe.

Handling

Tsukiji Market auction house experts advise that improvement in the quality of U.S.-processed sea urchin roe would enhance sales. Because the roe deteriorates quickly during shipment, they make the following recommendations:

1) Use only the best fresh roe. Deteriorated roe melts around the edges during the brining process and has a poor appearance.

2) Keep the temperatures of the processing room and the brine water low.

3) Drain the brine water well off the roe before putting it on the trays. Keep the roe color uniform in trays.

4) Avoid freezing at any point during shipment. Repeated freezing and thawing causes loss of firmness and poor appearance. (Source: IFR-89/36. Prepared by Karen Kelsky and Paul Niemeier of the NMFS Foreign Fisheries Analysis Branch, Silver Springs, MD 20910.)

THE JAPANESE ABALONE MARKET

Although abalone is expensive in Japan, it is popular among Japanese consumers, who eat it in sashimi, Chinese food, and holiday gift preparations. There are five major abalone species consumed in Japan. The United States was the fourth-largest exporter of abalone to Japan in 1988.

Species

Japan's major abalone species are the Japanese abalone or "kuro awabi," *Nor-*

dotis discus; the giant abalone or "madaka awabi," *N. gigantea*; Siebold's abalone or "mekai awabi," *N. gigantea seiboldii*; the northern abalone or "ezo awabi," *N. discus hannai*; the tokobushi abalone or "tokobushi," *Sulculus diversicolor*; and a subspecies of the tokobushi abalone known as the "fuku tokobushi," *S. diversicolor aquatilis*. Although the northern abalone is found in shallow coastal waters off northern Honshu and Hokkaido (at depths of less than 15 m), the other species are found in warmer waters at depths ranging from 10 to 50 m.

Japanese abalone is thick-shelled, has dark colored meat, and grows to approximately 20 cm in length. Although it is good to eat fresh or steamed whole, the meat is considered tough. Giant abalone also reach lengths of 20 cm, but the meat shrinks slightly when steamed. Siebold's abalone, which grows to 25 cm, is flatter than the other species and is consumed raw. Northern abalone has a relatively thin shell and is suitable for any type of preparation. Tokobushi abalone is smaller than the other species, growing to lengths of only 7 cm. Tokobushi is characterized by 7-8 open holes on the shell, whereas other species of abalone have only 3-4 holes.

Consumption

Abalone is extremely expensive in Japan, and is generally bought by restaurants for preparation as sashimi. Almost all species are considered suitable for sashimi, although Japanese consumers prefer abalone with tan-colored meat. Giant and tokobushi abalone are also used in preparations known as "ni-gai" or "ni-awabi", whole abalones cooked with fish broth and soy. "Ni-awabi" packed in plastic bags or cans is a popular choice for the winter gift season. A leading Japanese manufacturer produces over 500 metric tons (t) of various kinds of ni-gai annually for the Japanese gift market. Other popular preparations are abalone steaks sauteed in butter and abalone marinated in vinegar. Dried abalone is used for Chinese cooking. The Japanese demand for fresh abalone increases in the summer because the Japanese believe that the quality improves as the season progresses.

Marketing

Live abalone is sold at auctions in Japan, generally in sizes ranging from 150 to 500 g. The most popular size is 200-300 g. Live Japanese abalone commands the best prices—$22.90-$53.00 per kg (U.S.$1 = ¥131)—and is normally sold to luxury Japanese restaurants for sashimi. Japanese shippers of live abalone keep the abalone in tanks at water temperatures of 15-18°C without feeding for about a week before shipment. Depriving the abalone of feed is believed to slow down its metabolism, thereby reducing mortality rates during shipping. Another benefit of the premarketing feed cut is to enhance the flavor of the abalone by reducing odor and excessive fat caused by feeds. The precise duration of the feed cut depends on the size of species.

Imports

Japan imported over 56 t (valued at $1.7 million) of abalone in 1988. The leading suppliers were, by quantity, China (25 t), the Republic of Korea (19 t), Australia (9 t), and the United States (4 t) (Fig. 1).[1] By value, however, South Korea ($820,000) surpassed China ($690,000) by 17 percent, because of the higher quality of its abalone.

Imported abalone is said to be tougher than Japanese abalone, although live or fresh imports are considered more tender than the frozen product. Imports are generally not used for sashimi, but processed and canned. About 40,000 cartons of canned abalone are distributed in Japan annually[2]. U.S. abalone is not considered suitable for drying because the flavor is said to be insufficient to produce a quality broth.

Live California black abalone (>1 kg each) and pink abalone (about 2 kg each) were sold in the Tokyo Central Wholesale Market (TCWM) in September 1988 for about $12.20 per kg, and $17.50-20.60 per kg, respectively. Other U.S. species are unknown in Japan. A specialist at a TCWM auction house advised U.S. exporters that a premarketing feed cut of 3-4 days for black abalone and 7 days for pink abalone should help reduce mortality rates. He also suggested sorting both species according to size[3]. The recommended carton size is 10 kg, although sometimes 12 kg cartons may be packed to compensate for water loss during shipment. Imported abalone often loses about 20 percent of its original weight by the time it is sold at auction. The specialist suggested that U.S. exporters should begin with trial shipments of 100-200 kg, and increase the quantity to 400-500 kg per shipment later. Consistency in shipping quantity

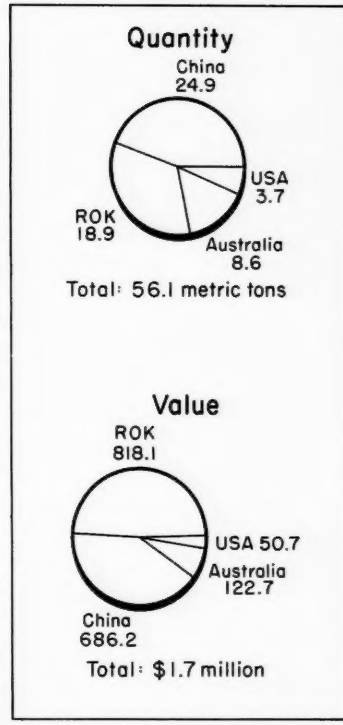

Figure 1.—Japanese imports of live, fresh, or chilled abalone, by country of origin, quantity (t) and value (US$1,000), 1988.

[1]Some of the U.S. imports may be Mexican-origin products shipped through Los Angeles, Calif.
[2]Canned abalone are packed 48 cans per carton, about 200 net per can.

[3]Abalone sizes are: L (400 g and up) and M (under 400 g) for the black abalone, and L (1 kg and up) and M (under 1 kg) for the pink abalone, unless U.S. exporters are unable to provide 200-300 g sizes.

and stable quality are important for Japanese buyers.

Tsukiji import houses import fish and seafood on a consignment basis and remit payment to exporters about 1 week after the auction. They deduct 5.5 percent commission, import duties, trucking charges, etc. They are authorized by Japan's Ministry of Agriculture, Forestry and Fisheries to sell to middlemen or wholesalers at auctions through bidding, bargaining, or at a fixed price. The goods may be consigned by producers or purchased by the auction houses from producers. The wholesaler's selling commissions are fixed at 5.5 percent for marine products. (Source: IFR-89/44R. Prepared by Karen Kelsky and Paul Niemeier of the NMFS Foreign Fisheries Analysis Branch, Silver Springs, MD 20910.)

MALAYSIAN SHRIMP CULTURE

Malaysian shrimp culture has begun to succeed commercially after suffering years of heavy financial losses. Improved aquaculture methods and the commitment of a few large companies are largely responsible for the turnaround. Malaysian production, mostly of giant tiger prawns[1], *Penaeus monodon*, was 1,260 metric tons (t) in 1987, almost five times the 1986 harvest of 270 t. Estimated 1988 production was 1,800 t. In 1987, Malaysia produced 300 million shimp post larvae for stocking growout ponds. Production of post larvae in 1988 was estimated at 360 million. Malaysia's post larvae production exceeds domestic shrimp farmers' needs, and the surplus is exported—about 78 million in 1987 and an estimated 11 million in 1988. About 80 percent of the Malaysian shrimp culture production is exported, mostly to Singapore, Japan, the United States, and Europe.

Production

Malaysian shrimp farmers harvested 1,260 t of shrimp in 1987, nearly five times the 1986 production (Table 1). Of this total 760 t were produced in peninsular Malaysia, and 500 t were produced in Sabah, East Malaysia. The estimated 1988 crop was 1,800 t, with 1,000 t produced in peninsular Malaysia and 800 t produced in Sabah. There are currently about 230 farms operating in Malaysia, covering a total of about 730 hectares (ha). In peninsular Malaysia, 190 farms are operating on 560 ha, and in Sabah, 36 farms cover about 170 ha. The Malaysian Government has targeted a total of 22,000 ha of mangrove swamp for development into aquaculture ponds, which are expected to yield 21,000 t of shrimp by the year 2000.

Most (about 85 percent) of the cultured shrimp produced in Malaysia are giant tiger prawns, and the remaining 15 percent are banana prawns, *P. merguiensis*. Both are grown in brackish water ponds.

Development Potential

Between 1986 and 1988, the government approved 36 shrimp aquaculture projects with a proposed investment of $122 million. Of this total, 23 projects, worth $102 million were approved in 1988 alone, indicating a dramatic rise in the stock of Malaysian aquaculture. If all 36 projects are completed, their combined production will be about 30,000 t annually, surpassing the government's official annual production goal of 21,000 t by the year 2000. Many of the projects are joint ventures with Taiwanese partners. Some of the larger projects have their own hatcheries, and some are integrated with processing plants. Projects have been sited in Sabah, as well as the states of Johore, Pahang, Trengganu, and Kelantan on the east coast, and Selangor, Perak, and Kedah on the west coast of peninsular Malaysia.

Corporate Investments

Three major corporations have located projects within a very small area at Kuala Sedili, in the state of Johore. They are: the Johore State Economic Development Corporation, which runs the East Asia Marine Farms (EAMF); the Anglo-Dutch Unilever Corporation; and the Lion Corporation, which also has shrimp farms in Malacca and Sabah, through holdings of its subsidiary, Aquabio.

U.S. Embassy officials in Kuala Lumpur recently visited the EAMF project and talked with its managing director, Ahamad Bin Mohamed. EAMF produced 420 t of shrimp on 200 ha (50 ponds of 4 ha each) in 1988 and is predicting 1989 production of 660 tons. It is expanding its Kuala Sedili operation by another 200 ha and is building a 450 ha farm near Mersing, Johore, for $18 million. EAMF uses the semi-intensive culture method, which has consistently yielded 600-700 kg of shrimp per ha annually in Malaysia. However, EAMF achieved yields of 915 kg per ha in 1988 and is currently producing 1,200 kg per ha annually. The company's goal is 2,000 kg of shrimp per ha, and it already has some ponds producing above this rate. EAMF's harvesting cycle is approximately 4½ months for each pond. Most of its efforts for increasing productivity are focused on reducing turnaround time; its equipment for cleaning and repairing ponds after harvesting becomes inoperable in the frequent rains.

Table 1.—Malaysian total shrimp production, by fishery with cultured shrimp as percentage of total shrimp production, 1983-1988, and 2000 projection.

	Shrimp production (t)			
Year	Wild catch	Cultured	Total	Percent[1]
1983	52,821	415	53,236	1
1984	53,650	682	54,332	1
1985	80,349	205	80,554	Negl.
1986	57,982	269	58,251	Negl.
1987	71,693	1,260	72,953	2
1988[2]	N/A[3]	1,800	N/A	N/A
2000[4]	N/A	21,000	N/A	N/A

[1]Cultured shrimp production as a percentage of total production.
[2]Estimated.
[3]N/A = Not available.
[4]Projected.

[1]*Penaeus monodon* are also marketed commercially as black tiger prawns. Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

EAMF currently imports shrimp feed from Taiwan but is constructing its own feedmill. Feed accounts for about 60 percent of production costs in Sabah and 40-50 percent of production costs in peninsular Malaysia. Sabah has recently announced that it will embark on a feed mill joint venture with an unnamed foreign partner.

EAMF is vertically integrated, with its own hatchery and processing plant. It would like to process shrimp from other projects, but currently a substantial percentage of Malaysian shrimp are shipped live for processing to Singapore where they command higher prices. EAMF processes and freezes its shrimp for shipment to Japan where they are marketed under both premium-brand and general-brand names.

According to EAMF's managing director, the Kuala Sedili-based Unilever and Lion shrimp farms have just gone into production. At present, Lion's farm is producing 2 t per month, and Unilever is producing 1 t per month. Lion's shrimp farms in Malaysia are expected to harvest a total of 100-150 t in 1989. The company plans to expand from the current 40 ha in production to over 1,200 ha within the next 5 years. Press reports state that the Unilever project will eventually cover 1,000 ha (150 ponds), yielding 1,200 t per year. Unilever's total investment is expected to be $39 million.

The increased profitablity of shrimp culture in Malaysia is largely because of better siting. Previous projects often failed because ponds were located in mangrove areas where pond excavation resulted in a level of water acidity that is lethal to shrimp. In contrast, the Kuala Sedili projects are located on a tidal river at the edge of a mangrove area where the soil is more suitable.

Despite identical siting, however, there is strong disagreement among the three companies on the best production methods. The Unilever project has higher capital costs because the company lines its ponds with concrete and uses more expensive pumping equipment. The American farm manager for EAMF believes these costs are unnecessary, citing a previous Unilever failure in Sri Lanka. However, an industry source (not associated with any of the three companies) believes that EAMF and Lion risk failure precisely because their less expensive approach leads to costly pond maintenance and significant down time.

Other than feed, the greatest expense for all three projects is the pumping of thousands of gallons of brackish river water in and out of the ponds to maintain proper oxygen levels and to flush them of waste. According to EAMF's, Ahamad, while the government is still endorsing the use of mangrove land for aquaculture, the cognoscenti in Malaysian aquaculture will be setting up on sites similar to Kuala Sedili. The east coast is dotted with relatively unpolluted tidal rivers with adjacent state land theoretically available for aquaculture.

Hatcheries

At present, 32 shrimp hatcheries are registered with the Malaysian Fisheries Department (23 in peninsular Malaysia and 9 in Sabah). Post larvae production in 1987 was 300 million (240 million in peninsular Malaysia and 60 million in Sabah). Estimated 1988 post larvae production is 360 million (280 million in peninsular Malaysia and 80 million in Sabah). Although 78 million post larvae were exported in 1987, it is estimated that only about 11 million were exported in 1988. The reasons for this decline are not known. The major foreign markets for Malaysian post larvae are Sri Lanka, Oman, Pakistan, Hong Kong, Italy, China, and Thailand.

Sabah dominates production of wild tiger prawn broodstock in Malaysia. Live gravid females sell locally for between $58 and $110, with prices going as high as $1,820 in Taiwan, the major export market[2]. (Tiger prawns accounted for 70 percent of Taiwan's shrimp exports to Japan and 29 percent of Southeast Asia's shrimp exports to Japan in 1987). Malaysia has banned the export of gravid shrimp, but smuggling them out of the country through Singapore is reportedly common.

Research

The Malaysian National Prawn Research Center was completed in 1987 with a $8.4 million grant from the Japanese Government. It has also received assistance from two Japanese aquaculture experts supplied by the Japanese International Cooperation Agency. The Center has cut shrimp post larvae production costs by 50 percent over the last 5 years, from $0.015 per fry to $0.007. A new technique for mass production of post larvae through induced spawning was developed at the Center and is being applied in most of Malaysia's hatcheries.

Government Incentives

The Malaysian government assists the shrimp culture industry through the Department of Fisheries, which provides advice and technical assistance. Shrimp culture firms are also eligible to receive the tax rebates and tax relief, which the Malaysian government provides to most developing industries. A 5 percent investment tax credit is extended to all shrimp culture investors, i.e., 50 percent of the first 5 year's qualifying capital expenditures may be deducted from taxable income. These expenditures include the clearing of land, pond construction, the purchase of plant and machinery, and building construction. Investors may also borrow from the government's new low-cost investment fund at reduced rates or benefit from a reduced interest rate export credit refinancing scheme.

Outlook

Malaysia will be pushing to join the ranks of major Asian shrimp producers over the next 10 years. Prospects are bright for continued investment now that the larger companies are beginning to demonstrate that shrimp aquaculture can succeed commercially in Malaysia. Whichever production method is employed, potential large players, such as plantation companies and state economic development corporations with foreign joint-venture partners, are likely to move into the shrimp culture business. (Source: IFR-89/50. Prepared by Karen Kelsky and Paul Niemeier of the NMFS Foreign Fisheries Analysis Branch, Silver Spring, MD 20910.)

[2]The official exchange used in this report is U.S.$1.00 = M$2.75.

High Quality Seafood, How to Maintain It, and Pacific Fish Yields

Some time ago the University of Alaska published a handy "White Fish Processing Manual" for commercial fishermen. To that they have now added the **"Handbook on White Fish Handling Aboard Fishing Vessels,"** by John P. Doyle and Charles Jensen, published as Marine Advisory Bulletin 36 by the Alaska Sea Grant College Program, University of Alaska, Fairbanks, AK 99775-5040. It is a companion also to MAP Bulletin 8, "Teaching Manual for Extension Course in White Fish Processing Technology" by Per O. Heggelund et al. ($7.00).

The material is designed for fisheries in cold to temperate regions and deals specifically with the species of the North Pacific Ocean and the Bering Sea. However, these basic principles of proper handling to achieve high quality seafood remain useful far beyond Alaskan waters, for the publications are designed to teach the commercial fisherman how to achieve the highest quality and long shelf life for his product.

Following introductory material defining intrinsic and extrinsic seafood quality and the ways that quality is lost, Doyle and Jensen delve into proper methods of catching, landing, and on-deck handling of fish to maintain high quality. Close attention is paid to stowage—icing, boxing, shelving, bulk stowage—giving advantages and disadvantages of the processes. Also reviewed are refrigerated and chilled seawater systems, freezing fish at sea, unloading the fish, cleaning and sanitizing the vessel, and useful references. This is an excellent handbook, well written and illustrated (price not listed).

Another in this series is Marine Advisory Bulletin 18, **"Care of Halibut Aboard the Fishing Vessel"** by Donald E. Kramer and Brian C. Paust. Like the previous bulletin, this one too is based on the latest scientific information and consultation with the fishing industry. It provides well illustrated guidance on the landing and onboard handling of this huge flatfish, bleeding and dressing of them, storage on ice and in RSW or CSW, onboard freezing methods, a discussion of the "chalky" halibut and yellow discoloration of belly surface problems and how to avoid them, fish hold design and modification, and vessel cleaning and sanitation. The 30-page paperbound handbook also includes several references for further reading (N/C).

Results of an experiment with salmon in RSW are reported in Marine Advisory Bulletin 34, **"Salmon Quality: The Effects of Elevated Refrigerated Seawater Chilling Temperatures"** by Chuck Crapo and Elisa Elliot. Here the authors report how slight temperature increases in the RSW system affect the quality of the salmon and what the storage limits are for these systems. Their laboratory study of the quality of salmon held in RSW at over 31°F also indicates how those higher temperatures affect fresh and frozen shelf life of the product. The 12-page paperbound bulletin costs $2.00 postpaid.

Marine Advisory Bulletin No. 37, **"Recoveries and Yields from Pacific Fish and Shellfish"** by Crapo, Paust, and NMFS scientist Jerry Babbitt is a unique guide to the average and expected range of product that is "lost" during various processing steps. Such yield and recovery data are useful in several ways—to determine whether roe herring are ready to be fished, to track the efficiency of a filleting operation by documenting daily recovery, to estimate the profitability of a new fishery or processing line, etc. The data provided have been extracted mostly from various scientific publications and represents the average yield from high quality, properly handled fresh fish and shellfish in good physiological condition. The reported ranges represent the typical variations found within fish populations during the year. Smoked fish yields were calculated using an average 15 percent weight loss during salting/brining and 10 percent in the smoking process. Data is provided for most of the important northeast Pacific commercial fishes and many less well known. The 50-page paperbound bulletin costs $5.00.

Another useful title for salmon fishermen is **"Recommended Salmon Quality Guidelines for Fishing, Tendering and Processing Operations"** by the Alaska Seafood Marketing Institute, Alaska Department of Commerce and Economic Development, P.O. Box DX, Juneau, AK 99811-0800. This 39-page paperbound manual provides specific guidance for salmon fishermen on ways to maintain high quality, providing recommended operating procedures for fishermen, chilling and chilled storage during fishing operations, freezing and frozen storage aboard fishing vessels, fishing vessel sanitation, tendering vessel guidelines and recommended operating procedures, chilling and chilled storage aboard tenders, and tendering vessel sanitation. Similar data is given for shore-based and floating processing facilities and operations (price not listed).

Aquaculture Prospects and Potential in Alaska

"Proceedings of the Fourth Alaska Aquaculture Conference", edited by Sue Keller, has been published as Report 88-4 by the Alaska Sea Grant Program, University of Alaska, Fairbanks, AK 99775-5040. While many contributions are specific to Alaska conditions, it also presents a number of finfish and shellfish reviews for more southerly parts of the Pacific coast, along with articles on seaweed culture.

In the seaweed section, contributions address *Laminaria* culture in British Columbia and *Laminaria* resources in Alaska. Others discuss the potential for *Macrosystis* and nori culture in Alaska. Oyster culture in Alaska and the Pacific Northwest is then reviewed, as is scallop

culture in British Columbia. Additional articles examine mussel culture in Alaska, littleneck clam culture in the Pacific Northwest, and abalone culture in the Pacific Northwest and its applicability to Alaska.

Results from sablefish culture experiments in British Columbia are related, as are various practical aspects such as nutritional requirements of farmed fish by Ron Hardy, relation of feed costs to finfish farming, diseases of saltwater-reared salmon, culture site selection, environmental effects of finfish cage culture, and more. Other sections treat business and financing and aquaculture permit aspects of mariculture. The 236-page volume is paperbound, and costs $8.00.

Another look at sea vegetables is presented in Marine Advisory Bulletin 27, **"Seaweed Cultivation in Minamikayabe, Hokkaido, Japan: Potential for Similar Mariculture in Southeastern Alaska,"** by Wallace M Olson. Minamikayabe claims to be the "Kombu Capital" of Japan, and this publication provides a good look at the area's seaweed industry which involves *Laminaria japonica* and *Kjellmaniella crassifolia*. Both are harvested wild, while *L. japonica* is cultured. Olson reviews culture and harvest techniques, processing, marketing and consumption, product forms and uses, and the economics of kombu culture and then discusses the potential for such operations in Alaska waters. The 23-page paperbound bulletin is well illustrated with photographs and drawings and costs $1.50. Additional information is available in the Alaska Sea Grant Program's Aquaculture Note series, with number 11 being "Where to Get More Information on Farming Marine Algae in High Latitude Waters" by Curt Kerns, which is a handy guide to sources of information on regulations, research assistance, pertinent publications, organizations working with seaweeds, and an indexed bibliography of 396 articles, books, theses, etc. on farming marine algae. Aquaculture Note 9, by Kerns, "Where to Get More Information on Small-scale Aquaculture," also provides basic information for those interested in starting out in fish and shellfish culture, listing 10 technical manuals on the topic and several other bulletins, articles, etc. on salmonid and molluscan shellfish and salmonid culture. The "Notes" cost $1.00 each. Another in the same series (no. 8) provides information on "Farming Salmon and Trout in Net Pens."

The European Markets for Cultured Fishes

The FAO's Globefish Research Program has begun a series of publications, the first of which is **"Markets in Europe for Selected Aquaculture Species: Salmon, Trout, Seabass, Seabream,"** by Susan A. Shaw and Adrienne Curry. The authors here examine the current European markets for these species and the prospects to 1993 for such nations as Belgium, the Netherlands, West Germany (FRG), France, Italy, Spain, and the United Kingdom.

Salmon consumption (fresh and frozen), they note, grew rapidly (more than 200 percent) between 1980 and 1987 in all surveyed nations (and in Spain alone by 800 percent). Rainbow trout showed similar increases. Seabass and seabream supplies played only a marginal role in total fish supply to European countries, but interest in developing the culture industry for those species is regarded as strong; they do bring premium prices, particularly in Italy. The 121-page paperbound issue, Globefish Research Programme Vol. 1, costs US$40 and is available from Globefish, FIIU, FAO, Via delle Terme di Caracalla, 00100, Roma, Italy; or, from INFOFISH, Wisman Pkns (9th Floor), Jalan Raja Laut, P.O. Box 10899, Kuala Lumpur, Malaysia.

Salmon Market Analyses in North America, Europe

Publication of **"An Econometric Analysis of Atlantic Salmon Markets in the United States and and France"** by Biing-Hwan Lin and Mark Herrmann has been announced by the Alaska Sea Grant College Program, University of Alaska, 138 Irving II, Fairbanks, AK 99775-5040. The United Sates is second to France as a consumer of cultured salmon and this report discusses the relationship between culture and imports of Atlantic salmon and the effect of it on the demand for Pacific salmon. Using mathematical models, the authors report that the U.S. demand for cultured Atlantic salmon is price and income elastic, that Atlantic salmon is a weak substitute for fresh chinook salmon in the United States, but the two products are not competitors in France, and that the current supply of Norwegian Atlantic salmon to the United States is determined by total Norwegian salmon culture production, previous supply to the United States, and prices paid by the United Satates and other importers. The 19-page paperbound report (88-5) costs $2.00 postpaid.

Another report by Lin is **"The Demand for Atlantic Salmon in Canada: Issues of Functional Form and Parameter Stability."** The results indicate that salmon stock enhancement programs can increase fishermen's revenues substantially, and that there is great potential for the growth of the farmed Atlantic salmon industry in Canada. A market analysis demonstrates that the Atlantic salmon is a luxury item that consumers consider a substitute for lobster (and vice versa). The 11-page report (88-6) also costs $2.00 postpaid.

To Catch an Octopus

"Fishing for Octopus, a Guide for Commercial Fishermen" by Brian C. Paust is another utilitarian handbook published by the Alaska Sea Grant Program, University of Alaska, Fairbanks, AK 99775-5040. It is, in short, a practical review of biological and fishing information keyed primarily to *Octopus dofleini*, but which also gives tips useful for catching other species. In Alaska, some octopus is sold for food, but much of the catch goes for halibut longline bait. In other areas, octopus is sought for certain ethnic food markets or even for export.

Paust reviews octopus biology and life history, harvest and use worldwide, octopus fishing strategies, and fishing gear selection. Discussed is his Alaska octopus fishing investigation and its results;

listed also are persons who can provide further information and economic factors facing development of an octopus fishery. Methods of handling and dressing octopus on small vessels are included, along with a list of selected references. Published as Report No. 88-3, the 48-page paperbound manual costs $5.00.

PROBLEMS WITH OCEAN DEBRIS

Marine debris, often of plastic, comes from many sources, some even fisheries related. One publication addressing this problem is **"Persistent Marine Debris, Challenge and Response: The Federal Perspective,"** which is available from the NOAA Office of the Chief Scientist, 14th Street and Constitution Avenue, Room 6222, Washington, DC 20230. Published by the Alaska Sea Grant College Program, it presents material drawn from the larger "Report of the Interagency Task Force on Persistent Marine Debris."

With data and charts, this 41-page color booklet looks at the scope of this problem and its environmental effects, the sources of marine debris, the threat to wildlife and fishes from it, the effects on humans, what different governmental and private groups are doing to combat marine debris problems, and then lists the recommendations of the Federal task force for Federal leadership, a public awareness/education program, implementing laws on marine debris, research and monitoring, and beach clean-up and monitoring.

Another publication is **"Oceans of Plastic, Report on a Workshop on Fisheries-Generated Marine Debris and Derelict Fishing Gear,"** from a 1988 conference in Portland, Oreg. This report outlines the problems of marine plastic pollution and the fishing industry's role in it; it then presents some specific steps for a solution: Financial incentive systems regarding gear discarding or loss/recovery; a bounty system to reward fishermen bringing in their old gear or that found at sea; educational incentives for port personnel and seamen; and technological efforts such as recycling plastics, developing or using degradable plastics, and marking nets to determine ownership. Appendices provide the text of Robert W. Schoning's opening remarks and documents submitted to the workshop for background information on the issue. The 68-page paperbound volume, Alaska Sea Grant Report No. 88-7, costs $5.00.

Another practical handbook for local action on the problem is Alaska Sea Grant Education Publication No. 3, **"A Guide to Cleaning up Beach Debris in Alaska."** This 16-page booklet lists the steps needed to organize a local beach clean-up—funding, forming committee, setting dates and a theme, providing incentives, getting publicity, needed supplies and logistics, precautions, and sources of materials and further information (N/C).

Marine Pollution and What to Do About It

Problems with oceanic pollution, coastal erosion, and estuarine development, are chronic and sometimes severe. Many of them are detailed in **"The Wasted Ocean"** by David K. Bulloch, published by Lyons & Burford, 31 West 21 Street, New York, NY 10010. One in the "Coastal Waters Series" of the American Littoral Society, this is not an environmental scare-story book; rather, it is more a citizen's handbook for marine protection and conservation that relates certain pollution problems to make its points.

The author, a former president of the American Littoral Society, begins with a brief overview of marine problems, and a look at the pollutants carried to the sea by rivers. This leads to a discussion of various stresses on estuarine resources and consequent biological changes. Another chapter addresses the problems with the coastal and high seas ecosystems. The various laws, regulations, and agencies that attempt to deal with problems of marine pollution and coastal development are also reviewed.

A latter chapter presents "the aquaphile's agenda," a review of major marine/coastal environmental issues that several environmental groups have agreed on as top priorities in coastal issues, including wetlands protection, reducing pollution at the source, stopping subsidies of flood-plain/estuarine development, setting up an "aquafund" to rehabilitate heavily polluted areas, and enforcement of environment protection laws. This is capped by a chapter on how the average citizen can become involved in helping to protect and restore coastal and marine environments. Appendices outline Federal pollution control and clean water statutes, agencies concerned with coastal waters, environmental groups active on coastal issues, and a glossary of assorted acronyms for terms or phrases that will be encountered in the process. Indexed, the 150-page paperbound handbook costs $9.95 and is a straightforward and useful guide for citizens who want to work for a cleaner, healthier, and more productive marine environment.

A Guide for the Coastal Angler

Another of the American Littoral Society Books published by Lyons and Burford, 31 West 21 Street, New York, NY 10010, is **"The Compleat Surfcaster"** by C. Boyd Pfeiffer, former president of the Outdoor Writers Association of America and a well known angling writer. Subtitled "Tackle, Strategies, and Techniques," this is a fine introductory guide to a popular segment of marine recreational angling. Unusual, but welcome in outdoors books, is a brief annotated bibliography which would also benefit the beginning angler.

Beyond the usual information on tackle and techniques, Pfeiffer presents some good data on surf-fishing safety (an entire chapter), including thoughts on sportsmanship, courtesy, and conservation; useful tips on preventing or taking care of problems with saltwater corrosion, and directions on modification and repair of surf gear.

The author begins with a review of basic spinning and casting tackle for the surf fisherman, proper riggings and terminal tackle, and baits. Then follow chapters on lures, other needed gear and

clothing, surf casting techniques, reading the surf, beach buggies, fishing from jetties, piers, and bridges, and other types of surf fishing. A final chapter gives basic data on the popular surf-caught species and recommended tackle, baits, lures, and hook sizes for them.

Very well illustrated with both photographs and line drawings, the book provides good technical details on how to cast for both distance and accuracy. This excellent paperback handbook for the beginning coastal angler runs 200 pages and costs $14.95.

A New Journal on Natural Hazards

The International Society for the Prevention and Mitigation of Natural Hazards has announced its new official scientific publication, entitled *Natural Hazards*, edited by M. I. El-Sabh of the University of Quebec at Rimouski, Can., G. Schneider, University of Stuttgart, F.R.G.; and Y. Tsuchiya, Kyoto University, Japan.

The journal is devoted to original research on the physical aspects of various natural or environmental problems, including many oceanic ones affecting scientists, mariners, and fishermen. Articles will discuss the physical aspects of various natural hazards, the statistics of forecasting catastrophic events, risk assessment, and the nature of precursors of natural and/or technological hazards.

Hazards of interest to be treated in the new journal included in such sections as: Atmospheric, Climatological, Oceanographic, Storm Surges, Tsunamis, Floods, Snow, Avalanches, Earthquakes, Volcanoes, Man-made Technological, Risk Assessment, and others. Analytical papers will be published, as well as those on statistical techniques, case studies, and some state-of-the-art reviews. Departments include related meetings reports, publications, a natural hazards chronicle, announcements, and indexes to names and keywords. Recent papers have been on seismic intensity zoning and earthquake risk mapping, estimation of tsunami hazards from volcanic activity, possible future Pacific tsunamis, and storm surges in the Arabian Gulf.

Published by Kluwer Academic Publishers, P.O. Box 358, Accord Station, Hingham, MA 02018-0358, the journal is available by individual subscription or membership at $59.00 or by institutional subscription at $127.50, c/o Dr. S. Venkatesch, Treasurer, Natural Hazards Society, Environmental Prediction Research Section, Atmospheric Environment Service, 4905 Dufferi Street, Downsview, Ontario, Canada M3H 5T4.

History and Sociology of the B.C. Fisheries

Publication of **"Uncommon Property, the Fishing and Fish-Processing Industries in British Columbia,"** edited by Patricia Marchak, Neil Guppy, and John McMullan, formerly a Methuen Publications book, has been announced by the University of British Columbia Press, 6344 Memorial Road, Vancouver, BC, Canada V6T 1W5.

This is primarily a review of the social and economic structures of the Canada's west coast fishing industry, which includes considerable historical data and information for a broader perspective. And its insights into the political economy, sociology, and anthropology of commercial fishing makes it a much more different contribution than just a review or statistical analysis of such a fishery.

The volume sprang from a 3-year project by the University of British Columbia's Department of Anthropology and Sociology, in which the authors surveyed various fishing communities and groups including unions and Native Americans, as well as data on domestic and international markets, historical materials, the work of the Pearce Commission and much more.

The book is divided into three parts with part one devoted to the history of the industry, the role of the Federal and provincial governmental groups in it, raw fish markets and the processing sector, international markets and the British Columbia fisheries role in them.

Part 2 reviews and discusses the labor sector, with chapters on shore workers and fishermen and their working conditions, the history of their labor organizations, the role of the Native Americans in the fisheries, and the United Fishermen and Allied Workers Union newpaper's published perspective on the BC. fisheries. Part 3 then discusses the fishing communities themselves, and the effects on them, their responses to declining catches, and their viability. In sum, the authors have provided a unique reference with broad insights into the fisheries of Canada's west coast. The 424-page book is paperbound and is sold by the UBC Press for $21.95.

A Reference Guide to Crayfish Literature

Publication of **"An Interdisciplinary Bibliography of Freshwater Crayfishes"** by C. W. Hart, Jr., and Janice Clark has been announced by the Smithsonian Institution Press, 470 L'Enfant Plaza, Suite 7100, Washington, DC 20560. This is a very comprehensive listing of publications on these important crustaceans, with 12,481 listings and considerable updating since it was first published just a couple of years ago. Hart is a curator of Invertebrate Zoology at the Smithsonian's National Museum of Natural History and Clark is a Museum Specialist with the NMNH's Department of Invertegrate Zoology.

Crayfish, of course, are widely popular as a food item, at least in Europe and parts of the southern United States where they are also farmed. They are also much used by scientists; indeed, the largest single category of references in this book relate to neurophysiological work. Aquaculture papers also make up a large part of the listings, as might be expected. The breadth of the bibliography, however, makes it even more interesting. It includes citations ranging from motion pictures on the crayfish to poetry, yabbie farming in Australia, juvenile and adult literature references to the crayfish, musical items lauding it, postage stamps honoring the species, cookbooks, and more. Thus, this is a one-stop shopping guide to the literature on crayfish from Algicides to Zoogeography. Most important, of course, are the references to the vast and growing scientific literature; in just two years the

authors added nearly 1,300 references. Each citation presents the author(s), date, title of the reference, journal or publisher, and pagination. Also listed are alphanumeric subject codes, genera or species discussed (where known), and, for some, very brief explanatory notes. Each citation is numbered for index reference, and they are arranged alphabetically by author, then by date.

This very thorough, excellent 498-page guide to the crayfish literature is hardbound and available from the publisher for $35.00.

Safety and Insurance for Fishing Vessels

Alaska Sea Grant Report 88-2 presents the **"Summary Proceedings of the National Workshop on Fishing Vessel Insurance and Safety,"** Brenda R. Melteff, coordinator. The volume contains the summaries of transcripts from the workshop which addressed commercial fishing vessel safety and interactions with vessel insurance. Discussions on fishing vessel insurance aspects, alternative insurance systems in operation, and developing alternative insurance systems were printed separately as Alaska Marine Advisory Bulletin 31, "Self-insurance programs for the commercial fishing industry."

The workshop provided a forum for exchange of a wide variety of ideas, opinions, and suggestions for improvement of fishing vessel safety and on the need for and ways to obtain insurance on fishing vessels, as well as on safety education for fishermen. Included are discussions of legislative and regulatory aspects of the issues and alternative insurance systems (both currently operating and those then under development). Overviews of safety training programs are provided, as is a discussion of who is responsible for fishing safety. Also given are insurance brokers' views on insuring the fishing industry and national and international perspectives on fishing vessel insurance. The 173-page paperbound report is available from the Alaska Sea Grant Program, University of Alaska, Fairbanks, AK 99775-5040 and costs $8.00.

Photographic ID of the Humpback Whales

Photo identification of individual humpback whales has grown in use and a guide for that is **"Humpback Whales of the Central and Eastern North Pacific,"** subtitled "A Catalog of Individual Identification Photographs," which is edited by Anjanette Perry, Joseph R. Mobley, Jr., C. Scott Baker, and Louis M. Herman. The authors are affiliated with the University of Hawaii's Kewalo Basin Marine Mammal Laboratory and the volume is published by the University's Sea Grant College Program, 1000 Pope Road, MSB 200, Honolulu, HI 96822.

While the catalog is the greatest part of the book, the text accompanying it provides good background and reference information on the distribution of humpback whales in the world's oceans, their status prior to protection from whaling, and the locations where the photographs for the catalog were made. A section on the use of natural markings tells how scientists have used color and marking patterns to identify individual whales within a population.

Another section explains how the whales and their flukes are photographed and how comparisons between the photos are made. Also included is a summary of research findings on the species' natural history, including their seasonal migrations, estimates of abundance, and remarks on reproductive roles and social behavior. An appendix summarizes protective legislation for preventing whale harassment by vessels.

But it is the 158-page catalog of whale-tail photographs, 8 per page, provided by many marine mammal specialists, that forms the core of the book. The vast majority are from Hawaii (634) and Southeastern Alaska (464). Ninety-five photographs came from the western Gulf of Alaska, 36 from Mexican waters, and just 18 from California—the species' five major feeding or breeding areas. A total of 1,247 photographs are published, and a photograph of a particular whale appears only once within a region, but if photographed also in another region, that photo is printed there too. A total of 105 whales were resighted in more than one region, and a second Index II provides the resight numbers of these whales, and lists the regions where each one was sighted. The observation index (Index I) is organized by observation number, and when using the catalog, a specific photograph should first be referenced using that number. Cost of the plastic-bound, 233-page volume is $15.00 and it will probably be used widely by both scientific and recreational watchers of the humpback whale.

Editorial Guidelines for the *Marine Fisheries Review*

The *Marine Fisheries Review* publishes review articles, original research reports, significant progress reports, technical notes, and news articles on fisheries science, engineering, and economics, commercial and recreational fisheries, marine mammal studies, aquaculture, and U.S. and foreign fisheries developments. Emphasis, however, is on in-depth review articles and practical or applied aspects of marine fisheries rather than pure research.

Preferred paper length ranges from 4 to 12 printed pages (about 10-40 manuscript pages), although shorter and longer papers are sometimes accepted. Papers are normally printed within 4-6 months of acceptance. Publication is hastened when manuscripts conform to the following recommended guidelines.

The Manuscript

Submission of a manuscript to *Marine Fisheries Review* implies that the manuscript is the author's own work, has not been submitted for publication elsewhere, and is ready for publication as submitted. Commerce Department personnel should submit papers under a completed NOAA Form 25-700.

Manuscripts must be typed (double-spaced) on high-quality white bond paper and submitted with two duplicate (but not carbon) copies. The complete manuscript normally includes a title page, a short abstract (if needed), text, literature citations, tables, figure legends, footnotes, and the figures. The title page should carry the title and the name, department, institution or other affiliation, and complete address (plus current address if different) of the author(s). Manuscript pages should be numbered and have 1½-inch margins on all sides. Running heads are not used. An "Acknowledgments" section, if needed, may be placed at the end of the text. Use of appendices is discouraged.

Abstract and Headings

Keep titles, heading, subheadings, and the abstract short and clear. Abstracts should be short (one-half page or less) and double-spaced. Paper titles should be no longer than 60 characters; a four- to five-word (40 to 45 characters) title is ideal. Use heads sparingly, if at all. Heads should contain only 2-5 words; do not stack heads of different sizes.

Style

In style, the *Marine Fisheries Review* follows the "U.S. Government Printing Office Style Manual." Fish names follow the American Fisheries Society's Special Publication No. 12, "A List of Common and Scientific Names of Fishes from the United States and Canada," fourth edition, 1980. The "Merriam-Webster Third New International Dictionary" is used as the authority for correct spelling and word division. Only journal titles and scientific names (genera and species) should be italicized (underscored). Dates should be written as 3 November 1976. In text, literature is cited as Lynn and Reid (1968) or as (Lynn and Reid, 1968). Common abbreviations and symbols such as mm, m, g, ml, mg, and °C (without periods) may be used with numerals. Measurements are preferred in metric units; other equivalent units (i.e., fathoms, °F) may also be listed in parentheses.

Tables and Footnotes

Tables and footnotes should be typed separately and double-spaced. Tables should be numbered and referenced in text. Table headings and format should be consistent; do not use vertical rules.

Literature Cited

Title the list of references "Literature Cited" and include only published works or those actually in press. Citations must contain the complete title of the work, inclusive pagination, full journal title, and the year, month, volume, and issue numbers of the publication. Unpublished reports or manuscripts and personal communications must be footnoted. Include the title, author, pagination of the manuscript or report, and the address where it is on file. For personal communications, list the name, affiliation, and address of the communicator.

Citations should be double-spaced and listed alphabetically by the senior author's surname and initials. Co-authors should be listed by initials and surname. Where two or more citations have the same author(s), list them chronologically; where both author and year match on two or more, use lowercase alphabet to distinguish them (1969a, 1969b, 1969c, etc.).

Authors must double-check all literature cited; they alone are responsible for its accuracy.

Figures

All figures should be clearly identified with the author's name and figure number, if used. Figure legends should be brief and a copy may be taped to the back of the figure. Figures may or may not be numbered. Do not write on the back of photographs. Photographs should be black and white, 8 × 10 inches, sharply focused glossies of strong contrast. Potential cover photos are welcome, but their return cannot be guaranteed. Magnification listed for photomicrographs must match the figure submitted (a scale bar may be preferred).

Line art should be drawn with black India ink on white paper. Design, symbols, and lettering should be neat, legible, and simple. Avoid freehand lettering and heavy lettering and shading that could fill in when the figure is reduced. Consider column and page sizes when designing figures.

Finally

First-rate, professional papers are neat, accurate, and complete. Authors should proofread the manuscript for typographical errors and double-check its contents and appearance before submission. Mail the manuscript flat, first-class mail, to: Editor, *Marine Fisheries Review*, Scientific Publications Office, National Marine Fisheries Service, NOAA, 7600 Sand Point Way N.E., Bin C15700, Seattle, WA 98115.

The senior author will receive 50 reprints (no cover) of his paper free of charge and 50 free copies are supplied to his organization. Cost estimates for additional reprints can be supplied upon request.

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